# VACUUM DEMAND FLOW VALVE

## DESCRIPTION

### Related Applications

The present application claims priority from and is a Continuation-In-Part Application of U.S. Patent Application No. 10/414,412, filed on April 14, 2003, and entitled, "Vacuum Demand Flow Valve" which is a Continuation-In Part of U.S. Patent Application No. 10/096,083, filed on March 12, 2002 and entitled "Vacuum Demand Flow Valve," which is a Continuation-In-Part Application of U.S. Patent Application No. 09/880,721, now U.S. Patent No. 6,554,023, entitled "Vacuum Demand Flow Valve," and also claims the benefit of U.S. Provisional Application No. 60/400,501, filed on August 1, 2002, and entitled, "Vacuum Demand Flow Valve," which applications are expressly incorporated herein by reference and made a part hereof.

### Technical Field

The present invention relates generally to valves used in conjunction with fluid containers or tubing, and more specifically to a valve having a vent associated with a fluid container and being actuated by a vacuum.

### Background Prior Art

Fluid containers are widely used throughout the world and come in many forms. Such fluid containers are made from a variety of materials and are used for numerous purposes. For example, containers are commonly used to contain fluids such as water, soft drinks, sports drinks, alcoholic beverages and the like for individual consumer use and consumption. Fluid containers are also widely used in other applications such as in a medical setting. For example, fluid containers are used in hospitals to provide nutritional fluids to patients who cannot eat solid food. Also fluid containers contain a variety of material used in industry and various mechanical arts such as engines and the like.

A drawback to using such containers is the contents of the container can be easily spilled and, therefore, wasted. Not only are the contents lost but fluid spills can damage the surface the fluid contacts. Spilling of fluid contents is a particularly common occurrence for patients in a

hospital setting. The patients can be under sedation or other medication that causes drowsiness or disorientation. The patients can also often drift into an involuntary unconscious state while consuming the nutritional products. This can result in spillage of the nutritional product over the patients' bedding requiring changing of the bedding and cleaning of the spillage. FIG. 1 shows a variety of settings where fluid spills can occur. For example, fluids contained in drink pouches or drink boxes popular with children can be spilled through the straw supplied with the containers. Additionally, one is familiar with the problems arising with fluid spills in an industrial setting, wherein the spill of a caustic or dangerous chemical causes significant clean-up expense as well as placing workers in a potentially hazardous position.

Some fluid containers may be supplied with a closure such as a threaded cap. Such closures, however, normally must be open and/or closed manually by hand. This makes it difficult for consumers to use during certain activities such as running or cycling, or if consumers are carrying several other items that cannot be put down. Other closures have been developed that can be automatically actuated but are difficult to use. Such containers are also not economical to manufacture to be used with disposable fluid containers.

The present invention is provided to solve these and other problems.

**Summary of the Invention**

The present invention provides a vacuum demand flow valve capable of dispensing a flowable material. In one preferred embodiment, the vacuum demand flow valve is attached to a drink container.

According to one aspect of the invention, a valve includes a member subject to a first force operative to keep the valve closed, said member being sensitive to an index pressure. The valve has an outlet at a second pressure, said index pressure providing a second force in opposition to said first force when a differential between said second pressure and said index pressure is provided to the member. The valve opens when the second pressure is sufficiently less than the index pressure to overcome the first force. A vent is operably associated with the member, and opens when the valve is opened.

According to another aspect of the present invention, a valve for accessing the contents of a fluid container includes a housing defining at least a portion of a passageway between an outlet opening and an inner opening, and a member being deflectable from a first position to a second

position associated with the housing. The valve further includes a stop connected to the deflectable member, wherein when the deflectable member is in the first position, the stop is in sealing contact with the inner opening to close the inner opening, and when the deflectable member is in the second position, the stop is spaced from the inner opening to open the inner opening to allow fluid to flow there through. The valve also includes a vent operably associated with the stop, the vent opening when the deflectable member is in the second position.

According to another aspect of the present invention, a valve for accessing the contents of a fluid container includes a housing defining at least a portion of a passageway between an outlet opening and an inner opening, and a member being deflectable from a first position to a second position associated with the housing. The valve further includes a stop connected to the deflectable member, wherein when the deflectable member is in the first position, the stop is in sealing contact with the inner opening to close the inner opening, and when the deflectable member is in the second position, the stop is spaced from the inner opening to open the inner opening to allow fluid to flow there through. The valve also includes means for venting the fluid container associated with the stop.

According to another aspect of the present invention, the valve comprises a member having a stop. The stop provides a first force operative to keep the valve closed. The member is sensitive to an index pressure. An outlet is at a second pressure. The index pressure provides a second force in opposition to the first force when a differential between the second pressure and the index pressure is provided to the member. The valve opens when the second pressure is sufficiently less than the index pressure thereby overcoming the first force.

According to another aspect of the present invention, the valve closes under action of the second pressure when the index pressure provides the second force to the member of a magnitude less than that of the first force. According to another aspect of the present invention, the valve closes under action of the second pressure when the second pressure on the member is substantially equal to the index pressure.

According to another aspect of the present invention, the member includes a diaphragm. According to another aspect of the present invention, the stop is cooperative with an internal opening to selectively control flow of a flowable material.

According to another aspect of the present invention, the index pressure is ambient.

According to another aspect of the present invention, the member has a channel therethrough and the channel is subject to the index pressure.

According to another aspect of the present invention, the stop is further subject to a third force generally equal to and opposite the first force.

According to another aspect of the present invention, the valve is in communication with a fluid container having a container pressure. The stop is configured such that the stop is subjected to generally equal and opposite forces from the container pressure. According to another aspect of the invention, the stop provides the first force independent of the container pressure.

According to another aspect of the invention, when the valve is closed, the stop is subjected to forces placing the stop in a balanced condition.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

Brief Description of the Drawings

FIG. 1 shows a plurality of schematic views illustrating problems encountered with prior art fluid containers;

FIG. 2 is a perspective view of a vacuum demand flow valve of the present invention attached to a flexible fluid container;

FIG. 3 is a perspective view of the container of FIG. 2 showing removal of a tamper evident strip;

FIG. 4 is a perspective view of the valve and container wherein a cap of the valve is removed;

FIG. 5 is a partial cross-sectional view of the valve and container, the valve being shown in a closed position;

FIG. 6 is a partial cross-sectional view of the valve and container, the valve being placed in an open position by a user;

FIG. 7 is a partial cross-sectional view of the valve and container, the valve returned to a closed position;

FIG. 8 is a schematic view of the valve of the present invention; and

FIG. 9 is a partial cross-sectional view of the valve and container, the valve adapted to be placed in an open position via a syringe;

FIG. 10 is an exploded perspective view of another embodiment of the vacuum demand flow valve of the present invention;

FIG. 11 is a partial cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention and the container, the valve being shown in a closed position;

FIG. 12 is a partial cross-sectional view of the valve and container of FIG. 11, the valve being placed in an open position by a user;

FIG. 13 is a partial cross-sectional view of the valve and container of FIG. 11, the valve returned to a closed position;

FIGS. 14a-d are cross-sectional views showing assembly of the valve of FIG. 10;

FIG. 15 is an exploded perspective view of another embodiment of the vacuum demand flow valve of the present invention;

FIG. 16 is a cross-sectional view of the valve of FIG. 15, the valve being shown in a closed position;

FIGS. 17a-c are cross-sectional views showing assembly of the valve of FIG. 15;

FIG. 18 is an exploded perspective view of another embodiment of the vacuum demand flow valve of the present invention;

FIG. 19 is a cross-sectional view of the valve of FIG. 18, the valve being shown in a closed position;

FIGS. 20a-d are cross-sectional views showing assembly of the valve of FIG. 18;

FIG. 21 is a perspective view of another embodiment of the vacuum demand flow valve of the present invention attached to a flexible fluid container;

FIG. 22 is a partial perspective view of the container of FIG. 21 showing removal of a tamper evident strip;

FIG. 23 is a perspective view of the valve and container wherein a cap of the valve is removed;

FIG. 24 is a partial cross-sectional view of the valve and container of FIG. 21, the valve being shown in a closed position;

FIG. 25 is a partial cross-sectional view of the valve and container of FIG. 21, the valve being placed in an open position by a user;

FIG. 26 is a schematic view of a user consuming a fluid from a container having a vacuum demand flow valve of the present invention;

FIG. 27 is perspective view of a vacuum demand flow valve of the present invention attached to a fluid container, the valve having an indicia-bearing surface;

FIG. 28 is a perspective view of another vacuum demand flow valve of the present invention attached to a fluid container, the valve having an indicia-bearing surface;

FIGS. 29a-c are schematic views showing various uses of the vacuum demand flow valve of the present invention;

FIG. 30 is a schematic view showing another use of the vacuum demand flow valve of the present invention;

FIG. 31 is a schematic view showing another use of the vacuum demand flow valve of the present invention;

FIG. 32 is a schematic view showing another use of the vacuum demand flow valve of the present invention;

FIGS. 33a-b are schematic views showing additional uses of the vacuum demand flow valve of the present invention;

FIGS. 34a-d are schematic views showing additional uses of the vacuum demand flow valve of the present invention;

FIG. 35 is a schematic view showing another use of the vacuum demand flow valve of the present invention; and

FIGS. 36a-b are schematic views showing additional uses of the vacuum demand flow valve of the present invention.

FIG. 37 is a perspective view of another embodiment of the vacuum demand flow valve of the present invention, the valve attached to a fluid container;

FIG. 38 is a rear elevation view of the vacuum demand flow valve of FIG. 37;

FIG. 39 is a plan view of the vacuum demand flow valve of FIG. 37;

FIG. 40 is a side elevation view of the vacuum demand flow valve of FIG. 37;

FIG. 41 is an exploded perspective view of the vacuum demand flow valve of FIG. 37;

FIG. 42 is a cross-sectional view of the vacuum demand flow valve of FIG. 37;

FIG. 43 is a cross-sectional view of the vacuum demand flow valve with attached container showing the valve in a closed position;

FIG. 44 is a cross-sectional view of the vacuum demand flow valve with attached container showing the valve placed in an open position by a user;

FIG. 45 is a cross-sectional view of another embodiment of the vacuum demand flow valve having a modified stop member, the valve shown in a closed position;

FIG. 46 is a cross-sectional view of the vacuum demand flow valve of FIG. 45 showing the valve placed in an open position by a user; and

FIG. 47 is a cross-sectional view of the vacuum demand flow valve of FIG. 37 with attached container and having the modified stop member of FIG. 45, the valve being placed in an open position by a user.

FIG. 48 is a schematic diagram of alternative embodiments of the valve of FIG. 37;

FIG. 49 is an exploded perspective view of another embodiment of the valve of the present invention;

FIG. 50 is an exploded perspective view of another embodiment of the valve of the present invention;

FIG. 51 is a perspective view of another embodiment of the valve of the present invention having a cap thereon;

FIG. 52 is a schematic view of the valve of FIG. 51 having the cap removed;

FIG. 53 is a cross-sectional view of another embodiment of the valve of the present invention having a vent;

FIG. 54 is a cross-sectional view of the valve of FIG. 53 attached to a fluid container;

FIG. 55 is a cross-sectional view of the valve of FIG. 53 wherein the vent is in a closed position;

FIG. 56 is a cross sectional view of the valve of FIG. 53 as it appears during use;

FIG. 57 is a cross-sectional view of the valve of FIG. 53 wherein the vent is in an open position

FIG. 58 is a cross-sectional view of the valve of FIG. 53 attached to a fluid container having indented sides;

FIG. 59 is another cross-sectional view of the valve of FIG. 53 attached to a fluid container;

FIG. 60 is a cross-sectional view of another embodiment of the valve of the present invention having a vent;

FIG. 61 is a cross-sectional view of the valve of FIG. 60 wherein the vent is in a closed position;

FIG. 62 is a cross-sectional view of the valve of FIG. 60 wherein the vent is in an open position;

FIG. 63 is a cross-sectional view of the valve of FIG. 60 as it appears during use;

FIG. 64 is a cross-sectional view of the valve of FIG. 60 attached to a fluid container having indented sides;

FIG. 65 is a cross-sectional view of the valve of FIG. 60 attached to a fluid container;

FIG. 66 is a cross-sectional view of another embodiment of the valve of the present invention having a vent;

FIG. 67 is a cross-sectional view of the valve of FIG. 66 wherein the vent is in a closed position;

FIG. 68 is a cross-sectional view of the valve of FIG. 66 wherein the vent is in an open position;

FIG. 69 is a cross-sectional view of the valve of FIG. 66 as it appears during use;

FIG. 70 is a cross-sectional view of the valve of FIG. 66 attached to a fluid container having indented sides;

FIG. 71 is a cross-sectional view of the valve of FIG. 66 attached to a fluid container;

FIG. 72 is a cross-sectional view of another embodiment of the vacuum demand flow valve, attached to a container;

FIG. 73 is a partial cross-sectional view of the vacuum demand flow valve and the container of FIG. 72;

FIG. 74 is a partial cross-sectional view of the valve and container of FIG. 72, the valve in a generally open position;

FIG. 75 is a partial cross-sectional view of the valve and container of FIG. 72, the valve in a generally closed position;

FIG. 76 is a partial cross-sectional view of the valve and container of FIG. 72, the valve in a generally open position;

FIG. 77 is a partial cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention shown connected to a container;

FIG. 78 is a partial cross-sectional view of the valve and container of FIG. 77, the valve shown in a generally closed position;

FIG. 79 is a partial cross-sectional view of the valve and container of FIG. 77, the valve shown in a generally open position;

FIG. 80 is a partial cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention shown connected to a container;

FIG. 81 is a partial cross-sectional view of the valve and container of FIG. 80, the valve shown in a generally closed position;

FIG. 82 is a partial cross-sectional view of the valve and container of FIG. 80, the valve shown in a generally open position;

FIG. 83 is a partial cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention shown connected to a container;

FIG. 84 is a partial cross-sectional view of the valve and container of FIG. 83, the valve shown in a generally open position;

FIG. 85 is a partial cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention, the valve shown connected to a container;

FIG. 86 is a partial cross-sectional view of the valve and container of FIG. 85, the valve shown in a generally open position;

FIG. 87 is a partial cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention, the valve shown connected to a container;

FIG. 88 is perspective view of a valve stop member of the valve of FIG. 87;

FIG. 89 is a partial cross-sectional view of the valve of FIG. 87, the valve shown in a generally closed position; and

FIG. 90 is a partial cross-sectional view of the valve of FIG. 87, the valve shown in a generally open position.

## Detailed Description

While this invention is susceptible to embodiments in many different forms, there are shown in the drawings and will herein be described in detail, preferred embodiments of the invention with the understanding that the present disclosures are to be considered as exemplifications of the principles of the invention and are not intended to limit the broad aspects of the invention to the embodiments illustrated.

FIG. 2 discloses a vacuum demand flow valve, generally referred to with the reference numeral 10, attached to a flexible fluid container 11. It is understood that the valve 10 can be used with various types of containers that contain a flowable material or substance. Thus, the shape of the container 11 can be arbitrary. The structure of the valve 10 will first be described followed by a description of the operation of the valve 10. Other embodiments of the valve will also be described.

As shown in FIGS. 2-7, the valve 10 generally includes a housing 12. The valve 10 also includes a diaphragm 14, a stop 18, and a radially extensive plug 70 which, can be considered in combination to be a valve member. Similarly, equivalent valve members shall be subsequently shown in other embodiments of the instant invention having differing reference numerals. Also shown is a diaphragm cover 20 and a cap 21. The valve 10 is adapted to be connected to the container 11. The container 11 may be formed as to have a first sidewall 22 and a second sidewall 24. The valve 10 allows for dispensing flowable materials from the container 11. The container 11 defines a reservoir for holding flowable materials. As discussed in greater detail below, the diaphragm member 14 is a flexible member that can be actuated by a user through the use of a vacuum pressure or a positive, external force.

As shown in FIG. 5, the housing 12 has a generally tubular structure defining a passageway 26 for a flowable material to pass therethrough. The housing 12 has a first opening 28 defining a valve outlet and a second opening 30, or inlet opening 30 adapted to be in communication with the container 11. The passageway 26 is between the valve outlet 28 and the inlet opening 30. The housing 12 further generally has an upper wall 32 and a lower wall 34. The walls 32,34 of the housing 12 cooperatively define a first housing section 36 and a second housing section 38. The first section 36 defines a first chamber 40 and the second section 38 defines a second chamber 42. In certain embodiments, the passageway 26 can only comprise the first chamber 40. The first section 36 has a port member 44 that has one end defining the first opening 28 of the housing 12. The port member 44 is generally a tubular structure and is sized such that, in an embodiment that is adapted to be useable by a person directly, a user's mouth can fit comfortably over the port member 44. Thus, the port member 44 can be considered a mouthpiece for the user. In an embodiment that is adapted to be used in conjunction with a pump or a syringe, an appropriately shaped port member would be supplied. The port member 44 also has an orifice 46 having a lesser diameter than the remainder of the passageway 26. This will be described in greater detail below. The orifice 46

could comprise a plurality of orifices. It is understood that the nomenclature of the first and second sections and chambers can be reversed.

The housing 12 further has an internal, or intermediate wall 48 extending between the upper wall 32 and the lower wall 34. The intermediate wall 48 has an inner opening 50. The inner opening 50 can be considered a second opening. The intermediate wall 48 further has an underside surface 52. The intermediate wall 48 generally divides the housing 12 to define the first chamber 40 and the second chamber 42. The first chamber 40 can be considered a downstream side of the valve 10 and the second chamber 42 can be considered an upstream side of the valve. The inner opening 50 will be in communication with the fluid container 11 via the second chamber 42. The second chamber 42 can include the fluid container 11.

The upper wall 32 has a generally circular opening 54 defined by an annular rim 56. The circular opening 54 is adapted to receive the diaphragm 14 to be described in greater detail below. The annular rim 56 has a lip 58. A front portion of the annular rim 56 cooperates with a vertical wall 60 of the port member 44 to define a groove 62.

As further shown in FIG. 5, the diaphragm 14 is a resilient, deflectable member that in one preferred embodiment, is generally circular in shape. The diaphragm 14 has a central portion 64 and an annular peripheral edge 66 defining a flange 68. The diaphragm 14 is connected to the housing 12 and is received by the circular opening 54. The flange 68 cooperates with the lip 58 of the annular rim 56. The diaphragm 14 is slightly under-sized as compared to the annular rim 56 wherein the elastomeric properties of the diaphragm 14 ensure a seal between the diaphragm 14 and the rim 56. Once connected, the diaphragm 14 can be considered a portion of the housing 12 that is flexible and deflectable from a first position to a second position to open the valve 10 as described below as well as being capable of being biased towards the first position due to either the structural properties of the assembly or the mechanical properties of the diaphragm 14. Thus, in a preferred embodiment, the diaphragm 14 comprises the flexible portion of the housing 12.

As also shown in FIG. 5, the stop member 18 is generally a plug member having a flange 70 at one end. The stop member 18 depends from a central portion 64 of the diaphragm 14 and extends through the internal opening 50. The flange 70 abuts the underside 52 of the intermediate wall 48 to define a closed valve position. The flange 70 can be considered a plug that is radially extensive from the stop 18 and sized to close the inner opening 50. The plug, or flange 70 can be considered to be located toward an upstream side of the valve from the stop. The upstream side of

the valve can be considered generally at the second chamber 42 and the downstream side of the valve can be generally considered at the first chamber 40. In a preferred embodiment, the stop member 18 and the diaphragm 14 can be integrally molded together so as to form the valve member previously described. As described in greater detail below, the resiliency of the diaphragm 14 biases the stop member 18 against the internal opening 50 to define a closed valve position. The flange 70 abuts the underside surface 52 of the internal wall 48.

In one preferred embodiment, the valve 10 utilizes the diaphragm cover 20. The diaphragm cover 20 is positioned over the diaphragm 14. The diaphragm cover 20 has a collar 65 that fits around the flange 68 of the diaphragm 14. The diaphragm cover 20 can fit within the groove 62 at a front portion of the valve 10. The diaphragm cover 20 is sized to assist in the compression of the diaphragm 14 around the annular rim 56. The diaphragm cover 20 helps protect the valve 10 from accidental activation. As shown in FIGS. 2 and 3, if desired, the valve 10 can also be equipped with the cap 21 that is press-fit over the port member 44. A tamper evident sealing member 72 can also be included. The tamper evident sealing member 72 seals the cap 21 to the housing 12 and gives a visual indication of whether the valve 10 has been tampered with or previously manipulated. It is understood that the valve components can be connected through a variety of processes including radio frequency or ultrasonic welding as well as solvent bonding or other methods as appropriate for the materials used.

As discussed, in one preferred embodiment, the valve 10 is attached to a fluid container 11. The container may either be formed from a single web or may have a flexible first sidewall 22 and flexible second sidewall 24. In the configuration and as shown in FIGS. 2, 3, and 4, the valve 10 is inserted between peripheral edges of the sidewalls 22, 24. The upper wall 32 is generally connected to the first sidewall and the lower wall 34 is generally connected to the second sidewall 24.

As shown in FIG. 5, the container 11 is shown in a configuration having a single circumferential sidewall as may be formed by blow molding and the like.

Prior to operation of the valve 10, the cap 21 is secured to the housing 12 by the tamper evident strip 72. As shown in FIGS. 3 and 4, the tamper evident strip 70 is peeled away and the cap 21 removed to expose the port member 44.

FIGS. 5-7 disclose operation of the valve 10. In an initial state, and as shown in FIG. 5, the valve 10 is in a closed position wherein the stop member 18 is biased against the underside surface 52 to close the inner opening 50. The valve member is subject to a first force operative to keep the

valve 10 closed. In this first position, the first chamber 40 of the passageway 26 has a first volume V1. An external surface 15 of the diaphragm 14, and therefore the combination of the diaphragm 14, the stop 18, and the flange 70, which in combination can be referred to as a valve member, is generally subject to, and is sensitive to, an index pressure PI. The index pressure could be, for example, ambient pressure with the cap 20 being vented, or some other pressure resident in the interstice between the diaphragm 14 and the cap 20. The valve member is indexed against this index pressure PI. The first chamber 40 is also generally subjected to a pressure P1 which could be approximately equal to or greater than the index pressure PI.

The second chamber 42 and the container 11 may also be at an ambient pressure, or at some pressure substantially at or above the index pressure PI. The pressure in the second chamber 42 and container 11 may be referred to as PC. The pressure in the container 11 will not be substantially less than the pressure in the first chamber 40. As shown in FIG. 6, a user places their mouth over the port member 44 and reduces the pressure through the first chamber 40 of the passageway 26. This reduced pressure can be referred to as P2. The partial vacuum provides a pressure less than the index pressure. As shown in FIG. 6, the vacuum acts on a lower surface 74 of the diaphragm 14 causing the index pressure on the upper surface of the diaphragm to apply a force on the diaphragm 14 equal to the difference between the index pressure and the pressure of the partial vacuum times the area of the diaphragm 14, drawing it downwards. This moves the stop member 18 downwards in the direction of arrow A, and into the second chamber 42 towards the container 11. The flange 70 is spaced away from the inner opening 50 thus opening the valve 10. This occurs when the force applied overcomes a first force associated with the diaphragm 14 that maintains the stop member 18 to close the internal opening 50. This force may be, preferredly, a resilient spring force associated with the diaphragm structure or, in other embodiments, be due to an index pressure substantially below the initial pressure in the first chamber acting on the diaphragm 14; or a force due to pressure in the container 11 acting on the area of plug 70; or may be applied by an external means as exemplified by the spring 164 in FIG. 18. In this second position, the first chamber 40 of the passageway 26 has a second volume V2. The second volume V2 is less than the first volume V1 as the diaphragm 14 is moved closer to the intermediate wall 48. It is also understood the area between the diaphragm 14 and the cover 20 increases to a volume of V3 in this position. In this position, the flowable material such as a drink fluid, as shown, is allowed to flow from the container 11, through the inner opening 50 in the direction of arrow B, through the passageway 26 and out the

first opening 28 to be consumed by the user. Thus, when a vacuum is applied, a force is applied to the housing 46 in a first direction (arrow A) in response to the vacuum, thereby placing the passageway 48 in the second position, wherein fluid flows through the passageway in a second direction generally shown as arrow C in FIG. 6. Thus, when a differential between the second pressure and the index pressure is provided to the valve member, the valve 10 opens when the second pressure is sufficiently less than the index pressure to overcome the first force operative on the valve member. The container 11 is adapted to supply constant pressure when the valve 10 is open, such as a flexible container 11 or a rigid container having a vent. It is understood the valve 10 is operable even if the container is pressurized.

It can be further understood that the valve member is subject to a first force, as described hereabove, operative to keep the valve 10 closed. The valve member, i.e., the combination of the diaphragm 14, the stop 18, and the flange 70, supplies this biasing force as aforesaid. The valve member is sensitive to the index pressure. The outlet 28 of the valve 10 is subject to a second pressure. The index pressure provides a second force in opposition to the first force when a differential between the second pressure and the index pressure is provided to open the valve such that the second pressure is sufficiently less than the index pressure, multiplied by the area of the valve member, to overcome the first force. As shown in FIG. 6, the vacuum acts on a lower surface 74 of the diaphragm 14 causing the index pressure on the upper surface of the diaphragm to apply a force on the diaphragm 14 equal to the difference between the index pressure and the pressure of the partial vacuum times the area of the diaphragm 14, drawing it downwards. This moves the stop member 18 downwards in the direction of arrow A, and into the second chamber 42 towards the container 11. The flange 70 is spaced away from the inner opening 50 thus opening the valve 10. This occurs when the second pressure is sufficiently less than the index pressure wherein the force applied overcomes the resilient spring force or other sources of the force associated with the diaphragm 14 that biases the stop member 18 to close the internal opening 50.

As shown in FIG. 7, once the vacuum is removed, the valve 10 returns to the first or closed position. Thus, when the second pressure is substantially equal to or greater than the index pressure, the valve 10 closes. The resiliency of the diaphragm 14 biases the stop member 18 against the underside surface 52 of the intermediate wall 48 to close the inner opening 50 and therefore the valve 10. Fluid that passes through the port member 44, after the vacuum has been removed, is consumed by the user. The change between the first volume V1 and the second volume

V2 provides for an action that serves to withdraw the fluid from the outlet 28 back into the outlet passageway 29 such that the linear distance the fluid is withdrawn into the outlet passageway 29 is equal to the difference between the volume V2 and the volume V1 divided by the area of the outlet 28 which is sufficient to draw the fluid toward the passageway 26 and away from the outlet 28. Fluid that remains in the passageway 26 at the reduced diameter orifice 46 when the vacuum is removed, however, does not drip from the valve 10. The orifice 46 is sized in the port member 44 such that surface tension ST of the fluid across the orifice 46 maintains the fluid in the passageway 48 once the vacuum is removed. The molecules of the fluid will experience an inward force from the other fluid molecules wherein the fluid will act like an elastic sheet across the orifice 30. Molecules at the edges of the orifice will be attracted to the surfaces of the housing 12 defining the orifice 30. Thus, due to surface tension ST of the fluid, the fluid already in the passageway 26 cannot pass through the orifice 46 until a vacuum is again applied.

It can be understood that in this valve configuration as disclosed in FIGS. 2-7, the second chamber 42 of the passageway 26 of the valve 10 is in communication with the container 11. The second chamber 42 can include the container 11. The stop member 18 and the inner opening 50 can define a simple valve. In an initial state, the upper surface 15 of the diaphragm 14 is subject to an index pressure PI. In one embodiment, the index pressure PI can be ambient pressure. Also in the initial state, the first chamber 40 of the passageway 26 could also be under some different first pressure P1 or the index pressure PI. The second chamber 42 would be under a second pressure PC which also could typically be ambient pressure. The container 11 is also initially under the container pressure PC. This pressure could be ambient pressure. When a partial vacuum is applied, the first chamber 40 is now under a second pressure P2 that is less than the index pressure PI. In this state, the valve moves from a closed position to an open position wherein the fluid is allowed to flow through the outer opening 50. Thus, the valve operates to selectively place the first chamber 40 into communication with the second chamber 42. Accordingly, a differential pressure is applied across the diaphragm 14 causing the valve 10 to open and allow fluid to pass through the opening 50. In one preferred embodiment, the pressure differential occurs from ambient pressure, wherein the index pressure is at ambient pressure and the housing chamber is subjected to a negative pressure. Thus, the valve 10 is actuated by applying a pressure less than ambient pressure. It is understood that a pressure differential could also be applied from an initial pressure not equal to ambient pressure. One could also consider the index pressure a third pressure wherein the first

chamber is subject to a first pressure and the second chamber is subject to a second pressure at least substantially equal to the first pressure. The valve is indexed against the third pressure. The valve operates to selectively place the first chamber into communication with the second chamber when the first pressure is less than the third pressure, or index pressure. FIG. 8 further illustrates the pressures, and forces associated with the pressures, that act on the valve member during operation of the valve 10. The index pressure exerts an index force FI on an outer surface of the diaphragm 14. Prior to operation, the first chamber has a first pressure P1 and a first force F1 acting on an inner surface of the diaphragm 14 serving to balance the remaining forces acting on the valve. The container pressure PC and container force FC also acts on the valve member at the plug 70. A biasing force FB also acts on the valve member and is, in certain embodiments, supplied by the structure of diaphragm 14. When the first pressure P1 is reduced to a new pressure P2, a force F2 (less than F1) is applied to the diaphragm 14. The resultant force acting on the diaphragm 14 to open the valve 10 can be represented by the following vector formula: FR (resultant force) = AD(PI -P2) - AP(PC) - FB wherein AD is the area of the diaphragm 14 and AP is the area of the plug 70.

It is understood that the valve 10 can operate without utilizing the diaphragm cover 20. FIG. 8 discloses a simplified version of the valve 10 wherein a diaphragm cover 20 is not used. The diaphragm 14 can comprise a flexible portion of the housing 12. Upon actuation, this housing portion would flex to move the stop member 18 away from the inner opening 50.

It is further understood that the vacuum to actuate the valve 10 is typically applied by a user reducing the pressure through the passageway 26. The vacuum could also be applied by other means such as a syringe 51 as shown in FIG. 9. A vacuum could also be applied by a pump or other mechanical means. Finally, it is understood that the designations of "first" and "second" with respect to the chambers, pressures and valve positions can be interchanged.

In an alternative method of valve actuation, a user can depress the diaphragm 14 through the cover 20 to move the stop member 18 away from the inner opening 50. Fluid is then allowed to pass through the passageway 26 and out the outer opening 28.

It is understood that the valve 10 can be incorporated into a tubing. A portion of the tubing can be flexible and provide the diaphragm 14. An opposite portion of the tubing can be provided with the opening 50 to be communication with the container 11. The stop member 18 can be provided between the diaphragm 14 and opening 50.

It is further understood that the valve 10 could be constructed with multiple chambers and diaphragms or connected to a manifold designed to be in communication with separate chambers of a multi-chambered container. Different fluids, stored separately, could then be consumed together.

The valve components can be made from a variety of materials. The materials can be selected based on the intended use of the valve 10. In one embodiment, such as the valve being used with drink containers, the valve components can be made from a variety of polymers or other structurally suitable materials. Other materials are also possible. The choice of materials is only related to the fluid and use the valve is to be applied to. For example, should this valve be used in the fuel or oxidizer supply section of a rocket engine with an injection pump providing a partial vacuum and the index pressure externally applied; the valve member and housing may be made out of stainless steel.

FIGS. 10-14 disclose another embodiment of the vacuum demand flow valve of the present invention, generally referred to with the reference numeral 100. The vacuum demand flow valve 100 is similar to the valve 10 disclosed in FIGS. 2-7 and similar elements will be referred to with identical reference numerals. As shown in FIG. 11, the upper wall 32 of the housing 12 has the generally circular opening 54 defined by the annular rim 56. Proximate a front portion of the housing 12, the upper wall 32 has a first vertical wall 102. The first vertical wall 102 cooperates with the annular rim 56 to define a first groove 104. Proximate a rear portion of the housing 12, the upper wall 32 has a second vertical wall 106. The second vertical wall 106 cooperates with the annular rim 56 to define a second groove 108. As discussed previously, the diaphragm 14 is connected to the annular rim 56 wherein the flange 68 cooperates with the lip 58 of the annular rim 56. The diaphragm cover 20 is positioned over the diaphragm 14 wherein the collar 65 fits around the flange 68 of the diaphragm 14. The diaphragm cover 20 fits snugly within the first groove 104 and the second groove 108. FIG. 12 shows the valve 100 in an open position wherein a partial vacuum has been applied through the passageway 26. It is understood that the stop 18 as shown in FIG. 12 is structured to allow flow through the inner opening 50 and out the outlet opening 28. In FIG. 13, the vacuum has been removed wherein the valve 100 returns to a closed position as discussed above. The fluid is drawn back into the orifice wherein it will not drip out of the valve 100.

FIGS. 10 and 14 disclose a slightly modified diaphragm cover/cap assembly 110. In this design, the assembly 110 has a collar 112, a cap 114 and a diaphragm cover 116. The collar 112 is

connected to the cap 114 by a tamper evident strip 118 similar to the tamper evident strip 72 in FIG. 3. The diaphragm cover 116 is connected to the collar 112 by a flexible strap 120. FIGS. 14a-d disclose a general assembly of the valve 100. The diaphragm 14 is first connected to the housing 12 as discussed above. The cover/cap assembly 110 is then connected to the housing 112. The collar 112 and cap 114 are slid over the port assembly 44 of the housing 12. The diaphragm cover 116 is then pivoted and connected over the diaphragm 14 as shown in FIG. 14d. Prior to operation of the valve 110, the tamper evident strip 118 can be torn away to remove the cap 114 from the collar 112 to expose the port member 44 of the housing 12. The valve 100 is operated as described above.

FIGS. 15-17 disclose another embodiment of the vacuum demand valve of the present invention, generally designated with the reference numeral 130. In this embodiment, the port member of the housing is separated and connected instead to the diaphragm member 14. As shown in FIGS. 15 and 16, a port member 132 is integrally connected to a diaphragm 134. A collar assembly 136 is provided having a collar 138, a housing 140 and a diaphragm cover 142. The housing 140 is connected to the collar 138 by a first flexible strap 144. The diaphragm cover 142 is connected to the collar 138 by a second flexible strap 146. The collar assembly 136 also has a tamper evident strip 148 connecting a cap 150 to the collar 138. FIGS. 17a-c disclose a general assembly of the valve 130. The port member 132 is inserted into the collar assembly 136. The housing 140 is pivoted about the first flexible strap 144 wherein the stop member 18 connected to the diaphragm 134 is inserted into the internal opening of the housing 140. The port member 132 and diaphragm 134 are connected to the annular rim 56 on the housing 140. The diaphragm cover 142 is pivoted about the second flexible strap 146 and connected over the diaphragm 134. The valve 130 is operated as described above.

FIGS. 18-20 disclose another embodiment of the vacuum demand valve of the present invention, generally designated with the reference numeral 150. As shown in FIG. 18, the valve 150 has a diaphragm cover/cap assembly 152. In this design, the assembly 152 has a collar 154, a cap 156 and a diaphragm cover 158. The collar 154 is connected to the cap 156 by a tamper evident strip 159 similar to the tamper evident strip 72 in FIG. 3. The diaphragm cover 158 is connected to the collar 154 by a flexible strap 160. The valve 150 utilizes a housing 161 and a diaphragm 162. The diaphragm 162 is biased towards a closed position by a spring 164. The spring 164 is positioned around the stop member 18 wherein one end abuts the intermediate wall of the housing 161 and another end abuts an underside surface of the diaphragm 162. FIGS. 20a-d disclose a

general assembly of the valve 150. The spring 164 is on the intermediate wall of the housing 161 and the diaphragm 162 connected to the housing 162 via the annular rim 56. The housing 161 is inserted into the assembly 152 as shown in FIG. 20c. The diaphragm cover 158 is then pivoted via the flexible strap 160 and connected over the diaphragm 162. FIG. 19 shows the valve 150 utilizing a separate diaphragm cover 158 similar to the valve construction shown in FIG. 11. The valve 150 is operated as described above.

FIGS. 21-25 disclose yet another embodiment of the vacuum demand valve of the present invention. This valve, generally referred to with the reference numeral 200, is shown attached to a flexible fluid container 211. It is understood that the valve 200 can be used with various types of containers that contain a flowable material or substance. The structure of the valve 200 will first be described followed by a description of the operation of the valve 200.

As shown in FIG. 24, the valve 200 generally includes a port member 212, a first member or diaphragm member 214, a second member or base member 216, a stop member 218, a diaphragm cover 220 and a cap 221. The valve 200 is adapted to be connected to the container 211 that has a first sidewall 222 and a second sidewall 224. The valve 200 allows for dispensing flowable materials from the container 211. As discussed in greater detail below, the diaphragm member 214 is a flexible member that can be actuated by a user through the use of a vacuum pressure or a positive, external force.

As further shown in FIGS. 24 and 25, the port member 212 is generally a tubular structure and defines an outlet or outer opening 226. The port member 212 is sized such that a user's mouth can fit comfortably over the port member 212. In one preferred embodiment as shown in FIG. 23, the port member 212 has an elliptical shape. The port member 212 has a disk-shaped member 228 having an orifice 230 (FIG. 24).

The base member 216 is an elongated member that extends from a bottom portion of the port member 212. The base member 216 has a first end 232 that extends from the port member 212. A second end 234 of the base member 216 is connected to one end of the diaphragm 214 at an intermediate location 236 to be described in greater detail below. The base member 216 has an inner opening 238. The inner opening 238 will be in communication with the fluid container 211. The diaphragm 214 is a flexible member having one end 240 extending from an upper portion 242 of the port member 212. The diaphragm 214 has a second end 244 that is connected to the end 234 of the base member 216 at the intermediate location 236. As will be discussed in greater detail

below, in one preferred embodiment when the valve 200 is attached to a flexible container 211, the diaphragm 214 will comprise a portion of one of the flexible sidewalls 222. The base member 216 and diaphragm 214 collectively comprise a housing 246 of the valve 200. A portion of the housing 246 is flexible from a first position to a second position to open the valve 200. In a preferred embodiment, the diaphragm 214 comprises the flexible portion of the housing 246. The port member 212 could also be included as part of the housing 246. The base member 216 and diaphragm 214 also collectively define a passageway 248 of the valve 200.

The stop member 218 is positioned generally between the diaphragm 214 and base member 216 within the passageway 248. The stop member 218 has an arm 250 and a plunger 252 having a plug 254 at a distal end of the plunger 252. The arm 250 is hingedly connected to the port member 212 by a flexible strap 256. The plunger 252 is connected to a distal end of the arm 250. The plunger 252 and the arm 250 are connected to a bottom surface 258 of the diaphragm 214. The plug 254 is positioned through the inner opening 238 and abuts a bottom surface 260 of the base member 216 to close the inner opening 238. The plunger 252 further has a pair of resilient members 262. The resilient members 262 bias the plug 254 against the bottom surface 260 of the base member 216 so that the plug 254 abuts against the bottom surface 260 to close the opening 238.

In one preferred embodiment, the valve 200 utilizes the diaphragm cover 220. The diaphragm cover 220 is positioned over the diaphragm 214. The diaphragm cover 220 has a collar 264 positioned around the port member 212 and connected proximately thereto. An opposite end of the diaphragm cover 220 is connected to the diaphragm 214 at the intermediate location 236. The diaphragm cover 220 has a vent 266. If desired, the valve 200 can also be equipped with the cap 221 that fits over the port member 212. A tamper evident sealing member 270 can also be included. The tamper evident sealing member 270 seals the cap 221 against the collar 264 and gives a visual indication of whether the valve 200 has been tampered with or previously manipulated.

As discussed, in one preferred embodiment, the valve 200 is attached to a fluid container 211 having flexible first sidewall 222 and flexible second sidewall 224. In this configuration and as shown in FIGS. 24 and 25, the valve 200 is inserted between peripheral edges of the sidewalls 222,224. The end 234 of the base member 216 is connected to an underside surface 272 of the first sidewall 222 at the intermediate location 236. The first sidewall 222 extends further wherein its peripheral edge is connected to the valve 200 proximate the port member 212. In this

configuration, the portion of the first sidewall 222 extending from the intermediate location 236 to the connection proximate the port member 212 comprises the diaphragm 214. The bottom or second sidewall 224 is connected proximate the base member 216 at the port member 212 to seal the valve 200 to the container 211. The inner opening 238 is in communication with the inner chamber of the container 211 defined by the flexible sidewalls 222,224. It is understood that the valve 200 could have a diaphragm 214 constructed from a member separate from the sidewall 222.

Prior to operation of the valve 200, the cap 221 is secured to the valve 200 by the tamper evident strip 270. As shown in FIGS. 22 and 23, the tamper evident strip 270 is peeled away and the cap 221 is removed to expose the port 212.

FIGS. 24 and 25 generally disclose operation of the valve 200. In an initial state, and as shown in FIG. 24, the valve 200 is in a closed position wherein the plug 254 is biased against the bottom surface 260 to close the inner opening 238. In this first position, the passageway 248 has a first volume V1. The volume extends generally from the junction of the base member 216 and diaphragm 214 to the port member 212. A user places their mouth over the port member 212 and sucks to provide a partial vacuum through the passageway 248. The vacuum is a pressure less than an ambient pressure. As shown in FIG. 25, the vacuum acts on the lower surface 258 of the diaphragm 214 wherein the force associated with the index pressure forces the diaphragm 214 downwards. This moves the plunger 252 downwards in the direction of arrow A, wherein the plug 254 is spaced away from the inner opening 238 thus opening the valve 200. In this second position, the passageway 248 has a second volume V2. The second volume V2 is less than the first volume V1 as the diaphragm moved closer to the base member 216. It is also understood the area between the diaphragm 214 and the cover 220 increases to a volume of V3 in this position. In this position, the fluid is allowed to flow from the container 211, through the inner opening 238 in the direction of arrow B, through the passageway 248 and out the orifice 230 and outer opening 226 to be consumed by the user. Thus, when a vacuum is applied, a force is applied to the housing 246 in a first direction (arrow A) in response to the vacuum thereby placing the passageway 248 in the second position, wherein fluid flows through the passageway in a second direction generally shown as arrow C in FIG. 25.

Once the vacuum is removed, the valve 200 returns to the first position. The resilient members 262 bias the plug 254 against the bottom surface 260 of the base member 216 to close the inner opening 238 and therefore the valve 200. Fluid that passes through the orifice 230, after the

vacuum has been removed, is consumed by the user. Fluid that remains in the passageway 248 when the vacuum is removed, however, does not drip from the valve 200. The change between the first volume V1 and the second volume V2 provides for an action that serves to withdraw the fluid from the outlet 238 back into the outlet passageway 229 such that the linear distance the fluid is withdrawn into the outlet passageway 229 is equal to the difference between the volume V2 and the volume V1 divided by the area of the outlet 238 which is sufficient to draw the fluid toward the passageway 248. The orifice 230 in the port member 212 is sized such that surface tension of the fluid across the orifice 230 maintains the fluid in the passageway 248 once the vacuum is removed. The molecules of the fluid will experience an inward force from the other fluid molecules wherein the fluid will act like an elastic sheet across the orifice 230. Molecules at the edges of the orifice will be attracted to the surface of the disk-shaped member 228 defining the orifice 230. Thus, due to surface tension of the fluid, the fluid already in the passageway 248 cannot pass through the orifice 230 until a vacuum is again applied. In an alternative embodiment shown in FIG. 25, the port member 12 can have a venturi structure 231 generally at the port member 212.

It can be understood that in this valve configuration as disclosed in FIGS. 21-25, the passageway 248 of the valve 200 defines a first chamber while the container 211 defines a second chamber. The plug 254 and inner opening 238 define a simple valve. In an initial state, the upper surface of the diaphragm 214 is subject to a first pressure, or index pressure PI. The passageway 248 could also be subject to the index pressure PI or some other first pressure. In one particular embodiment, the index pressure could be ambient pressure. The container 211 is subject to a container pressure PC. The container pressure could also be at ambient pressure. When a partial vacuum is applied by a user as shown in FIG. 25, the first chamber defined by the passageway 248 is subjected to a second pressure P2 that is less than the index pressure PI. In this state, the valve moves from a closed position to an open position wherein the fluid is allowed to flow through the outer opening 26. In one preferred embodiment, the index pressure PI represents ambient pressure, which in an equilibrium state is present in the passageway 248 and the container 211. In this initial state (FIG. 24), the index pressure PI is generally under ambient pressure and the plug 254 closes the opening 238. When the second pressure P2 is applied to the passageway 248 that is less than ambient pressure, a vacuum is present. This results in a force acting on the diaphragm 214 as explained above drawing the diaphragm downwards wherein the plug 254 moves away from the opening 238 allowing fluid to pass through the opening 238. Thus, a differential pressure is applied

across the diaphragm 214 causing the valve 200 to open and allow fluid to pass through the opening 238. In one preferred embodiment, the pressure differential occurs from an index pressure that is ambient pressure. Thus, the valve 200 is actuated by applying a pressure less than ambient pressure. It is understood that a pressure differential could also be applied from an index pressure not equal to ambient pressure. It is also understood that the vacuum is typically applied by a user reducing the pressure through the passageway. The vacuum could also be applied by other means such as a syringe. A vacuum could also be applied by a pump or other mechanical means. Finally, it is understood that the designations of "first," "second" and "third" with respect to the chambers, pressures and valve positions can be interchanged.

In an alternative method of valve actuation, a user can depress the diaphragm 214 through the cover 220 to move the plug 254 away from the inner opening 238. Fluid is then allowed to pass through the passageway 248 and out the outer opening 226.

The valve components can be made from a variety of materials. In preferred form of the invention, the valve components are made from an injection-molded process wherein the port member 12, base member 16 and portions of the stop member 18 are integrally molded. It is understood, however, that the valve components can be formed separately and connected to one another.

It is understood that the valve 10 can be incorporated into a tubing. A portion of the tubing can be flexible and provide the diaphragm 14. An opposite portion of the tubing can be provided with an opening to be in communication with the container 11. A stop member can be provided between the diaphragm 14 and opening.

Thus, a device 10 (as well as the other disclosed devices) is provided that is simple in construction and use. As shown in FIG. 26, the valve 10 connected to a container 11 can be easily actuated by a user merely by applying a vacuum through the port member 12. Fluid is consumed as needed and will not drip from the valve 10. In addition, due to the construction of the device 10, fluid cannot be expelled through the valve 10 by squeezing the flexible sidewalls 22,24 of the container 11. To the contrary, squeezing the sidewalls 22,24 provides a greater seal as the plug 70 is forced further against the intermediate wall of the housing. Thus, if the container 11 is accidently compressed, fluid will not spray through the valve 10.

As shown in FIGS. 27 and 28, the valve 10 can be constructed wherein, for example, the diaphragm cover 20 can have a distinctive shape 180 (FIGS. 27 and 28) or an indicia-bearing surface 182 (FIG. 28) for promotional purposes or to provide for branding opportunities.

Containers utilizing the flowable material delivery device/valve of the present invention have a broad variety of uses and applications. The valve 10 is ideal for using with hot or cold drinks, as well as non-carbonated drinks. Users can easily carry such a container 11 on their person (FIGS. 29 and 30). Containers 11 holding, for example, juice or milk, can also be used for children and infants (FIGS. 29 and 32). The containers 11 can also have a hanger member 184 associated therewith. As shown in FIGS. 32 and 33a, the hanger member 184 may include a clamp 186 and a band 188 connecting the clamp 186 to the container 11. The clamp 186 can be removably affixed to a support member. The support member can include a plurality of different types of members such as in a vehicle (FIG. 33a) or a stroller (FIG. 32) such as for an infant. The container 11 can then be hung from the support member to be grasped by a user. As shown in FIG. 34c, the clamp 186 can also be directly attached to the container 11. The containers 11 can also be utilized in a number of different recreational settings (FIGS. 31 and 35). The containers 11 are also ideal when taking part in active sporting activities (FIGS. 34a-d). As shown in FIG. 34b and 34d, the container 11 could have a flexible tubing 190 attached thereto and a valve 10 attached to a distal end of the tube 190 wherein the tube 190 can be easily accessed hands-free such as when cycling or running. The container 11 can also be grasped with a single hand and the fluids consumed without further manual manipulation of the valve 10 (*See* FIG. 26). The containers 11 are further ideal to use when traveling (FIGS. 33a-b).

The container 11 can further be designed to stand upright in a predetermined position. As shown in FIG. 33b, the container 11 can also have a carrier 192 that can support the container 11 in a predetermined position. In one embodiment, the carrier 192 can have a base 194 and sidewalls 196. The carrier 192 may also have a handle 198. Finally, as shown in FIGS. 36a and 36b, the container 11 can be used by patients in a hospital setting. As further shown in FIG. 36b, an elongated tubing 199 can be attached to the container 11 with the valve 10 on the distal end of the tube. Uses also comprehended by the scope of the invention include storage and dispensing of industrial chemicals, medicaments or any other flowable material.

The valve 10 provides several benefits. The container 11 and valve 10 are low-cost and designed for single-use consumption wherein the container 11 and valve 10 can be discarded when

the container 11 is empty. The valve 10, however, could also be used in multi-use applications. The valve 10 is suction-activated wherein the user can drink through the valve 10 as easily as with a conventional straw. The housing structure and valve function also prevent dripping from the valve. The structure of the valve 10 prevents fluid from being drawn back into the container once through the internal opening. The structure of the valve 10 also resists pressure from the container 11 and cannot be accidently activated. The valve 10 is not required to be recapped once opened as the valve 10 returns to its closed position upon non-use. The valve components are easily manufactured such as by an injection-molded process in one preferred embodiment. Because the valve can be constructed from certain injection-moldable materials, the valve can be operable through a broad range of temperatures and for extended periods of time.

FIGS. 37-44 disclose another embodiment of the vacuum demand flow valve of the present invention, generally referred to with the reference numeral 300. The vacuum demand flow valve 300 is shown attached to fluid container 302 in FIG. 37. It is understood that the valve 300 can be used with various types of containers that contain a flowable material or substance. FIG. 37 shows one preferred embodiment of a fluid container 302 in the form of a container typically designed to hold a carbonated beverage such as soda pop. The container 302 could also hold other non-carbonated fluids as well.

As generally shown in FIGS. 41 and 42, the vacuum demand flow valve 300 generally includes a housing 304 and a flexible diaphragm member 306 having a stop 308. The housing 304 generally includes a port member 310 and a base 312.

As shown in FIGS. 38-42, the port member 310 of the housing 304 is generally tubular and defines a passageway 314 between an outlet opening 316 and an inlet opening 318. The port member 310 has a central portion 320 at a generally intermediate location of the port member 310. The central portion 320 has an inner groove 321. A spout 322 and a sloped wall 324 extend from one side of the central portion 320. The spout 322 defines a first portion 323 of the passageway 314. The passageway 314 may have an offset structure to achieve as small a profile as possible. This structure may be referred to as a core shut off. The port member 310 has an inner rim 326 on an inner surface of the sloped wall 324. The sloped wall 324 also has a vent opening 328. A vent chamber 329 is defined within the port member 310 and cooperatively formed with the diaphragm 306 as is shown in FIG. 42. An annular wall or skirt 330 extends from an opposed side of the central portion 320. The annular wall 330 has threads 332 on an inner surface. The annular wall

330 serves as an attaching member wherein the threads 332 are adapted for sealing engagement with a threaded opening of the fluid container 302. The spout 322 of the port member 310 is generally sized such that a user's mouth can fit comfortably over the port member 310. The port member 310 may be provided with a cap (not shown) that can be secured to the port member 310 prior to use. A tamper evident strip (also not shown) could be provided to seal the cap to the spout 322.

As shown in FIGS. 41 and 42, the base 312 has an internal wall 334 having an annular rim 336 extending therefrom. The internal wall 334 has an inner opening 338. The annular rim 336 has an aperture 340. A second portion 342 of the passageway 314 is defined between the inner opening 338 and the aperture 340. In one preferred embodiment, the second portion 342 of the passageway 314 is generally transverse to the first portion 323 of the passageway 314. The base 312 has a peripheral edge 342 that is received in the inner groove 321 in the central portion 320 of the port member 310. As shown, in a preferred embodiment, the base 312 is generally annular.

As further shown in FIGS. 41 and 42, the diaphragm 306 is generally a flexible member. The stop 308 is integrally formed with the diaphragm 306 and extends from a generally central portion of the diaphragm 306. The stop 308 passes through the inner opening 338 and has a flange 344 that is adapted to be in sealing contact with an underside surface 346 of the internal wall 334 to seal the inner opening 338. As shown in FIGS. 42, the diaphragm 306 is connected over the annular rim 336 and is sized such that the diaphragm 306 is in slight tension over the annular rim 336 to provide a sealed connection over the annular rim 336. The inner rim 326 of the port member 310 engages a top surface of the diaphragm 306. The diaphragm 306 is formed such that when connected to the annular rim 336, the stop 308 is biased against the internal wall 334 to seal the inner opening 338. Alternatively, a spring or other biasing member may be positioned between the internal wall 334 and the diaphragm 306. As discussed the vented chamber 329 is defined between the diaphragm 306 and the sloped wall 324 of the port member 310. As discussed in greater detail below, the diameters of the diaphragm 306 and stop 308 can be set within certain ranges wherein the valve 300 can be easily operated with a carbonated beverage container.

FIG. 43 shows the valve 300 and fluid container 302 wherein the valve 300 is closed. As shown, fluid 327 within the container 302 does not leak when the fluid 327 is in contact with the closed valve 300. The valve 300 is secured to the fluid container 302 by threads 332 which allow the valve to be screwed unto the container 302. In other embodiments, the valve may have flexible

semi-rigid members (not shown) which allow it to be snapped on. The valve may be glued on, or many other methods of attachment which immediately come to mind and are well known in the art may be used.

FIGS. 43 and 44 show the valve 300 connected to the container 302. The valve 300 operates similarly to the valves previously described and is subjected to similar pressures as previously described. However, when the container 302 holds a carbonated fluid, the pressure PC in container 302 is a positive pressure. As shown in FIGS. 43 and 44, the diaphragm 306 is deflectable from a first position S1 to a second position S2. When the diaphragm 306 is in the first position S1, the stop 308 is in sealing contact with the underside surface 346 of the internal wall 334 to close the inner opening 338. When the diaphragm 306 is in the second position S2, the stop 308 is spaced from the inner opening 338 to open the inner opening 338 wherein the carbonated liquid is allowed to pass through the inner opening 338 and through the second portion 342 and first portion 323 of the passageway 314. As discussed, the diaphragm 306 is preferably deflectable by a vacuum applied by a user as shown in FIG. 44. Because the container 302 holds a carbonated fluid under a positive pressure, the user must supply a sufficient vacuum to overcome the force applied to the stop 308 from the pressure in the container 302. By applying suction to the port member 310 by sucking, a typical user will provide in the range of from about -0.5 psi to about -1.25 psi of suction to the port member 310. In a preferred embodiment the amount of suction required to operate the valve 10 so that it is opened, is near to, or below, the lower end of this range. Most preferably, a user must supply about -0.3 psi of suction to open the valve 300. The stop 308 has a reduced diameter which lowers the force applied to the stop 308 against the internal wall 334 by the carbonated liquid in the container. This allows the valve 300 to be actuated at the desired range of suction pressures notwithstanding the pressure against the stop 308 from the carbonated liquid.

FIGS. 45 and 46 disclose another embodiment of the vacuum demand flow valve of the present invention, generally referred to with the reference numeral 400. The valve 400 has similar structure to the valves described above, but has a diaphragm 406 having a modified stop 408. The valve 400 has an internal wall 434 having an inner surface 435 defining an inner opening 438 The stop 408 has a frustoconical surface 410. As shown in FIG. 45, when the diaphragm 406 is in the first position, the frustoconical surface 410 is in sealing contact with the inner surface 435 of the inner opening 438. When in the open position as shown in FIG. 46, the stop 408 is spaced from the internal wall 434 to open the inner opening 438. FIG. 47 shows the stop 408 installed in a valve

similar to valve 300. An internal wall 440 has an inner surface 442 that is frustoconical. The frustoconical inner surface 442 is shaped to correspond to the frustoconical surface 410 of the stop 408. The mating frustoconical surfaces provide an enhanced sealing area.

The stop 408 is particularly suitable for valves used with containers holding carbonated beverages. The diaphragm has a diameter D1 and the stop 418 has a diameter D2. The stop diameter D2 is reduced to allow for easier opening of the valve. Thus, one way in which the suction required to operate the valve can be manipulated is by changing the ratio of the area of the diaphragm to the area of the stop. Carbonated beverages or other flowable materials may have a higher vapor pressure and subsequently a higher pressure in a container. This higher pressure will exert a greater force on the stop, assuming the same sized stop is used. This force acts to maintain the seal formed by the stop. To compensate for this additional force, the ratio of the diaphragm diameter D1 to the stop diameter D2 is preferably greater for use with containers containing flowable materials which create a higher pressure within the container. To change the ratio, either the diaphragm size can be increased, or the stop size decreased. In the preferred embodiment for use with flowable materials with a high vapor pressure, the stop size is decreased as shown in FIGS. 45-47 as compared to the stop shown, for example in FIG. 5. The stop size of the valve shown in FIGS. 42-44 can also be further reduced.

As discussed, the valve of FIGS. 37-52 are preferably suitable for use with carbonated beverage containers. The valves are suitable for carbonated beverages having pressures generally as high as 30-40 psi. Ratios for the diaphragm diameter D1 to the stop diameter D2 are generally in the range of from 80:1 to 5:1. For non-carbonated beverages, or those with a vapor pressure at or near ambient, a ratio in the range of from about 5:1 to about 15:1, or sub-ranges therein are preferred. A ratio of approximately 10:1 has been found most preferable. For carbonated fluids, a ratio in the range of from about 60:1 to about 80:1, or sub-ranges therein are preferred. A ratio of approximately 70:1 has been found most preferable. The ratio which is most preferable for a specific fluid and use will be that which ultimately places the suction required to activate the valve within the desired range, which may vary based upon the application for which the valve 10 is used. As stated above, generally the desired suction required to activate the valve is in the range of from about -0.3 psi to about -0.125 psi. In one preferred embodiment, a valve for a beverage container, such as the valve 300 in FIG. 37, has a diaphragm of approximately 20 mm and a valve stop of about 3.5 mm. The opening in the internal wall is approximately 3 mm. Accordingly, it can be

understood that with a carbonated beverage, the valve stop diameter is reduced from the valve stop diameter such as for the stop shown in FIG. 5. This reduces the force that the valve stop is subjected to from the vapor pressure of the carbonated beverage. Thus, the valve can still be opened by applying the desired suction within the range discussed above, notwithstanding that the container holds a carbonated beverage under pressure.

In more general terms, the valve can have an inlet at a first pressure and a valving member, such as the valve stop, reactive to said first pressure. The valving member is operatively connected to a second member, such as the diaphragm, which is sensitive to a second pressure such that said valving member selectively allows a fluid connection between said inlet and an outlet when a differential in pressure is applied to said second member so as to apply a force to said valving member greater than the force applied to said valving member by said first pressure, and an orifice, such as the internal opening of the internal wall, associated with said valving member sized as to allow said first pressure acting on said valve stop to be substantially reduced toward said second pressure.

FIG. 48 shows additional embodiments of the valve 300. In general, it is shown that the spout 322 of the port member 310 can be configured to various angled positions. The spout 322 is angled from a longitudinal axis L of the container. This can improve the flow and consumption characteristics of the valve and further improve the ergonomics associated with the valve design. Thus, as shown, a user can easily consume a beverage from the container without undue tilting of the head. The spout 322 can also be configured to a straight position.

FIGS. 49 and 50 also show additional embodiments of the valve that has similar internal structure as the valve 300. A port member 448 of the valve can have an opening 450 that is designed to be closed by a tear-away tamper evident seal member 452. The opening 450 can be wide (FIG. 49) or narrow (FIG. 50). The port member 448 can be designed to screw onto a threaded opening of a container.

Similarly, FIGS. 51 and 52 schematically show a valve 470 having similar structure as the valve 300. As shown in FIG. 51, the valve 470 can have a cap 472 such as used with a traditional disposable pop or water bottle. FIG. 52 shows the valve 470 with the cap 472 removed. It is understood that the internal structure of the valve 470 can be configured such that when one applies a suction to an opening 474, a force is applied to the appropriate side of the diaphragm in order to actuate the valve and provide a fluid passage through the valve.

Another embodiment of the valve of the present invention is shown in FIGS. 53-57. The valve is generally represented by reference numeral 500. The valve 500 generally has a housing 502 and a member 514. Generally, the member 514 is a deflectable member.

The housing 502 generally includes a port member 504 which defines an outer opening 506. The housing 502 may further include a base member 508 having an inner opening 510. The housing 502 generally defines at least a portion of a passageway 512 between the outer opening 506 and the inner opening 510. A chamber 548 is generally defined by the housing 502 and the deflectable member 514. The chamber 548 generally includes a vent 542 to the ambient environment which is remote from the outer opening 506. The housing generally includes threads 526, or other means for attaching the valve 500 to a fluid container.

As discussed, the valve 500 generally includes the deflectable member 514. The deflectable member preferably includes a diaphragm 515. The deflectable member 514 of this embodiment preferably forms a passageway 512 between itself and the housing 502 in communication with the outer opening 506. The member 514 may have a connected or integrally formed stop 516. The stop 516 preferably includes a plug 518, or sealing member, which fits within the inner opening 510.

The stop 516 may have a sealing member 518 formed from a molding process using a material which allows the sealing member 518 to be folded over from a first molded position (not shown) into a second position wherein it is used to seal an opening as shown in FIGS. 55 and 57. This type of stop is discussed in U.S. Patent Application Serial Number 10/095,894, entitled "Valve Stop," the contents of which are hereby incorporated by reference. The sealing member 518 in the molded position (not shown) is generally cone shaped with its base opening downwards. The sealing member 518 is then folded so that a sealing surface 536 can be used to form a fluid tight seal to plug the inner opening 510. It is understood that a valve stop of this type could be utilized in many of the embodiments described herein. In addition, such a valve stop could include a vent as described in detail below.

In this embodiment, a vent 520 is associated with the stop 516. The vent 520 generally includes a vent member 522. The vent member 522 is preferably incorporated to the stop 516, and generally integrally molded with the stop 516 during manufacture. The vent member 522 includes a base end 528 and a distal end 530 as shown in FIG. 55. The distal end 530 generally includes a sealable opening 532. The sealable opening 532 is generally an opening made proximate to, or at

the distal end 530. The opening is preferably a slit. The vent member 522 may be in the shape of a cone, truncated cone, i.e., frustoconical in shape, a wedge, or other shapes, and is generally hollow. In the embodiment shown in FIGS. 53-57, the vent member 522 includes an outer surface 534 which tapers from the base end 528 to the distal end 530. The distal end 530 generally extends into a fluid container 524.

FIG. 54 shows the valve of the present embodiment attached to a fluid container 524 in a vertical position having a fluid 538 therein. The threads 526 of the housing 502 are used to attach the valve 500 to the fluid container 524 as shown in FIG. 54. In use, the fluid container 524 is generally rotated to a horizontal position which brings the fluid 538 into contact with the valve 500 as shown in FIG. 56. A user 540 then generally applies a suction force to the port member 504. When a suction force is applied, the valve 500 opens, and liquid flows out of the fluid container 524 to the user 540.

In the present embodiment, activation of the valve 500 is based on pressure differentials which apply forces which cause the valve 500 to go from a closed to an open position. In the closed position, chamber 548 is generally at a first pressure P1, or index pressure. The designation of first, second, third and the like to pressures or structure is interchangeable in describing different embodiments, and the designations in this embodiment do not necessarily apply in others. The passageway 512 between the outer opening 506 and the inner opening 510 is at a second pressure P2, which is equal to P1 when no suction is applied to port 504. P1 and P2 are both at ambient pressure when no suction is applied to the outer opening 506 because passageway 512 is in communication with the outer opening 506, and chamber 548 is vented to the environment by vent 542. The fluid container 524 is generally at a third pressure P3. The vent 520 is generally exposed to the first pressure P1, and the third pressure P3. The pressure within the fluid container 524 tends to push the vent 520 together so that the sealable opening 532 remains closed as shown in FIG. 55. P3 may vary depending on the fluid stored in the container. When a carbonated beverage is stored in a fluid container, the vapor pressure created by the fluid is generally greater than when a non-carbonated beverage is stored in a container. Also, the vapor pressure of non-carbonated fluids dispensed by such a valve 500 may vary widely.

The first pressure P1 is generally ambient pressure provided by the environment surrounding the valve 500. The vent 542 is generally provided in the housing 502 to supply ambient pressure to the deflectable member 514. The first pressure generally acts on the deflectable

member 514 by pushing down on its top surface, and tends to push the deflectable member 514 downward, which would cause the plug 518 to move from the inner opening 510, opening the valve. However, the deflectable member 514 is subject to biasing forces which work counter to the first pressure P1, or index pressure, to keep the valve 500 closed. The biasing forces are generally supplied by the second pressure P2 in passageway 512, which is generally the same as the third pressure when no suction force is being applied to outer opening 506. In addition, the deflectable member 514 is also biased against the first pressure P1 by other forces, preferably provided by a resilient force associated with the structure of the deflectable member 514. The resilient force associated with the structure of the deflectable member 514, the second pressure P2, and the third pressure P3 acting upon the plug 518 from within a fluid container 524 all bias the deflectable member 514 to a first position wherein the valve 500 is closed.

When a user 540 applies a suction force to outer opening 506, the second pressure P2 within the passageway 512 is reduced. The reduction of the second pressure P2 allows the force supplied by the first pressure P1 acting on the deflectable member 514 to overcome the remaining biasing forces which generally keep the valve 500 closed. The deflectable member 514 then moves to a second position wherein the plug 518 moves from the inner opening 510. The valve 500 is then open, allowing fluid 538 to flow from the fluid container 524 through the inner opening 510, into the passageway 512, and out of the valve 500 through the outer opening 506.

When fluid 538 is removed from the fluid container 524 by, for example, a user 540 sucking some of the fluid through the valve 500, the third pressure P3 is reduced by the vacating of fluid. The vent 520 functions to equilibrate the first pressure P1, or index pressure, and the third pressure P3, or vapor pressure, by filling the space left by the vacated fluid. The vent 520 therefore opens when the ambient pressure is greater than the pressure within the fluid container 524 as shown in FIG. 57. A minimum activation pressure difference is generally required to overcome biasing forces within the vent 520 structure. Therefore, the pressure outside the container 524 may be slightly greater than the pressure within the container 524, yet the vent will remain closed until the minimum activation pressure difference is attained. When the pressure within the fluid container 524 is restored to a pressure where it is substantially equal to the ambient pressure, the vent 520 closes.

The vent 520 is preferably a one way vent which only opens when the ambient pressure is greater than the fluid container 524 pressure, but not vice versa. Therefore, when a carbonated

beverage or other high vapor pressure fluid is stored in the fluid container, the pressure within the fluid container 524 may be greater than ambient pressure, but the vent 520 of this embodiment will remain closed. When the pressure within the fluid container 524 is greater than the ambient pressure, the vapor pressure above the fluid 538 exerts a closing force on the vent member 522 which tends to push the sealable opening 532 to the closed position.

The addition of the vent 520 to the valve 500 has numerous functional benefits. The valve 500 of this embodiment used for dispensing fluid from a rigid container results in a constant flow rate of fluid from the container. The vent 520 prevents a "suck back" effect from occurring. If a vent is not present, the vacated volume of removed fluid may be filled by the evaporation of some of the remaining fluid, and the expansion of other gas remaining in the container. The pressure within the container will therefore be reduced overall, and relative to ambient pressure. As more and more fluid is removed, the internal pressure of the container will continue to decrease, and the removal of additional fluid will get progressively harder. While the valve will not necessarily be harder to open, when it is open, the suck back effect from the low pressure within the container will have to be overcome by the suction applied to the outer opening by a user. The flow rate would therefore decrease as progressively more fluid was removed from the rigid container if the vent 520 were not present. The undesirable suck back effect when withdrawing a fluid from a rigid container is reduced or eliminated through the use of the vent 520 incorporated into the valve 500. With a vented valve, the user 536 may use the valve 500 to remove fluid 538 from a container at a constant flow rate using a constant suction force applied to the outer opening 506, regardless of how much fluid has already been removed from the container.

It is often desirable to use the valve 500 of the present invention in conjunction with a semi-rigid container. A flexible plastic bottle 544 as shown in FIGS. 58-59 is one example of a semi-rigid container. When a user removes fluid 538 from the valve by sucking on the valve 500, or otherwise applying a suction force, they may simultaneously squeeze the flexible plastic bottle 544. This may cause the sides 546 of the plastic bottle 544 to indent. When a user has finished removing fluid 538 from the plastic bottle 544 it will have indented sides 546 as shown in FIG. 58. The elasticity of the plastic bottle 544 will generally allow the indented sides 546 to return to their original un-indented form, provided the pressure within the plastic bottle 544 is maintained as substantially equal to the pressure outside the flexible plastic bottle 544. The vent 520 of this embodiment allows the pressure within the bottle 544 to be maintained as substantially equal to, or

greater than, the pressure outside the bottle 544, even while the volume of the bottle is increasing from its indented volume to its original volume. Therefore, when a user 540 stops squeezing, air will begin entering through the vent 520, and the plastic bottle 544 will return to its original shape.

The same principle applies even if a user 540 did not squeeze the flexible plastic bottle 544, but simply removed fluid 538 from the bottle 544 without having a vent 520 to replace the vacated volume of the removed fluid. The sides 546 of the flexible plastic bottle 544 would again tend to indent due to the pressure differential between the interior and exterior of the bottle. However, the vent 520 prevents this undesirable indenting from occurring by replacing the removed fluid 538 with air from the environment. The vent 520 of this embodiment is capable of replacing the removed fluid with air simultaneous to the removal of the fluid. The vent 520 is exposed to ambient pressure by a vent 542 in the housing 502. This maintains the chamber 548 above the vent 520 at ambient pressure regardless of whether the valve 500 is opened or closed.

Another embodiment of a valve according to the present invention is shown in FIGS. 60-65 wherein the valve is generally shown by reference numeral 600. In this embodiment, the valve 600 includes a housing 602. The housing 602 generally includes a port member 604 which defines an outer opening 606. The housing 602 may further include a base member 608 having an inner opening 610. The housing 602 generally defines at least a portion of a passageway 612 between the outer opening 606 and the inner opening 610. A first chamber 609 is formed within the housing 602, and preferably, the housing 602 includes a vent 611 which vents the chamber 609 to maintain it at ambient pressure.

In this embodiment, the housing 602 includes an annular wall 614. The annular wall 614 preferably includes internal threads 616. Generally, the valve 600 of the present invention will be used in conjunction with a fluid container 618. The fluid container 618 preferably includes external threads 620 which cooperate with the threads 616 of the valve 600. The fluid container 618 also preferably includes a stop detail 622 which stops the annular wall 614 from being over tightened and moving too far down on to the fluid container 618.

The valve 600 generally includes a member 624. The member 624 is generally a flexible member associated with the housing as depicted in FIG. 60. The member preferably includes a flexible diaphragm 625. The member 624 of this embodiment preferably forms a passageway 612 between itself and the base member 608. The member 624 may have a connected or integrally formed stop member 626. The stop member 626 preferably includes a plug or sealing member 628.

The stop member 626 extends through the inner opening 610, and the sealing member 628 forms a fluid tight seal with the opening when the valve 600 is in a closed position.

In this embodiment, the valve 600 includes a lip seal vent 630 as shown in detail in FIGS. 61 and 62. The vent 630 is operably associated with the housing 602, and preferably includes a flexible vent member 632. The vent member 632 is preferably attached to the housing 600. When the valve 600 is fully seated onto the fluid container 618, the vent member 632 contacts a lip 634 of the fluid container 618. When the valve 600 is fully seated onto the fluid container 618, preferably a space is formed adjacent to the vent 630. The space is exposed to ambient pressure, and therefore exposes a back or exterior surface 636 of the vent member 632 to ambient pressure. A front, or interior surface 638, of the vent 630 is exposed to the interior of the fluid container 618. The front surface 638 is preferably in a generally "U" or "V" shape. The vent member 632 preferably includes arms 640 which extend towards the interior of the fluid container 618, and a base 642, which generally forms the back surface 636. One of the arms 640 is generally bonded or integrally formed with the housing 602. When the valve 600 is fully seated onto the container 618, another arm 640 is biased to contact the lip 634 of the container 618 by the resilient nature of the flexible member 632.

In the valve 600 of the present embodiment, activation of the valve 600 from a closed position to an open position is based on pressure differentials which apply forces to different parts of the valve 600. Ambient pressure outside of the container 618 is referred to as a first pressure P1, or index pressure. The first pressure P1 acts on the exterior surface 636 of the vent 630. The first pressure P1 also is present in the chamber 609, and acts on the flexible member 624. Passageway 612 is at a second pressure P2. When the valve is not in use, and is in a closed position, the passageway 612 is generally at ambient pressure. Generally this means a user 644 is not sucking, or otherwise applying pressure reducing suction, to the outer opening 606. The fluid container 618 is at a third pressure P3. The pressure within the fluid container 618 varies depending on what fluid is in the container 618 as discussed above.

The deflectable member 624 is subject to biasing forces which keep it in a first position wherein the valve is in a closed position. The biasing forces generally include a force provided by the second pressure P2 in passageway 612, by a resilient force associated with the structure of the deflectable member 624, and by the third pressure P3, which generally acts on the sealing member 628 from inside the fluid container.

When a user 644 applies a suction force to outer opening 606, the second pressure P2 within the passageway 612 is reduced. The reduction of the second pressure P2 allows the first pressure, or index pressure, to overcome the remaining biasing forces which keep the deflectable member 624 in the first closed position. The deflectable member 624 then moves to a second position, wherein the valve is open, allowing fluid 646 to flow from the fluid container 618 through the inner opening 610 into the passageway 612, and out of the valve 600 through the outer opening 606. It is understood that a second position is not one particular position, but rather any position wherein the deflectable member 624 is in a position such that the valve 600 is open. When the suction force to the outer opening 606 is terminated, the valve 600 again closes. As previously discussed with regard to earlier embodiments, the passageway 612 preferably is formed such that the surface tension of the fluid prevents any fluid 646 from escaping through the outer opening 606 once the suction force is terminated.

In this embodiment, the vent 630 is also opened in response to pressure differentials. The vent 630 is preferably a one way vent which only allows air to enter the fluid container 618 from the surrounding environment when the pressure inside the container 618 is less than the first pressure P1. The vent 630 does not allow gas or fluid to escape from the container 618. A minimum activation pressure difference is generally required to overcome biasing forces within the vent 630 structure. Therefore, the pressure outside the container 618 may be slightly greater than the pressure within the container 618, yet the vent 630 will remain closed until the minimum activation pressure difference is attained. When the pressure inside the fluid container 618 is substantially equal to or greater than the pressure outside the container 618, the vent 630 remains closed.

The lip seal vent 630 is shown in its closed and opened positions in FIGS. 61 and 62. As discussed, the closed position is maintained when the pressure within the fluid container 618 is substantially equal to or greater than the pressure pushing on the back surface 642 of the vent 630. The substantially equal or greater pressure within the container 618 pushes against the front surface 638 of the vent 630. Here, one of the arms 640 is bonded to the valve 630, and the other arm 640 is kept in contact with the lip 634 of the container 618 by the fluid container pressure, and also by a biasing force associated with the resilient nature of the material used for the vent member 632.

When the pressure outside of the fluid container is greater than the vapor pressure within the fluid container, the vent 630 is pushed open as indicated in FIG. 62. The arm 640 which was in

contact with the lip 634 is moved, and air enters the fluid container 618. The reduction of pressure within the fluid container 618 is generally caused by a user activating the valve 600 and removing some of the fluid 646 contained therein. The vent 630 preferably opens while the fluid 646 is being removed, and remains open until the pressure within the fluid container 618 has been raised to a point such that it is at least substantially equal to the pressure outside of the container 618.

Use of the valve 600 with the vent 630 as disclosed in this embodiment makes the valve 600 particularly useful in dispensing fluid from bottles which are commonly used to store beverages. One example of a commonly used container is a blow molded bottle made from polyester, polyethylene, or other blow molded polymers in which soda pop, water, or other beverages are contained. These types of containers are semi-rigid in that the sides can be indented with a relatively small amount of force, but have a tendency to spring back to their original shape. Therefore, when a vent is not used, and the pressure within the container is reduced relative to the outside pressure, the fluid container 624 will tend to indent as shown in FIG 64. However, use of a valve 600 having a vent 630 according to the present embodiment allows the pressure within the container 624 to be maintained at a level substantially equal to the outside pressure, providing a force which maintains the shape of the fluid container 624 as shown in FIG. 65, or at least restores the container 624 to its original shape as the vent 630 makes the pressures inside and outside of the container substantially equal.

In addition, use of the valve 600 with the vent 630 according to this embodiment prevents the undesirable suck back force discussed above, and provides a constant flow rate of fluid through the valve 600.

Another embodiment of the present invention is shown in FIGS. 66-71. The valve is generally represented by reference numeral 700. The valve 700 generally has a housing 702. The housing 702 generally includes a port member 704 which defines an outer opening 706. The housing 702 generally includes a base member 708 having an inner opening 710. The housing generally defines at least a portion of a passageway 712 between the outer opening 706 and the inner opening 710.

The valve 700 generally includes a deflectable member 714. The deflectable member 714 preferably includes a diaphragm 715. The member 714 of this embodiment defines a portion of a passageway 712 between itself and the base member 708. The deflectable member 714 preferably

includes a connected or integrally formed stop member 716. The stop member 716 generally includes a sealing member 718 which fits within the inner opening 710.

Associated with, or incorporated to the stop member 716, is a vent 720. The vent 720 of this embodiment is shown in detail in FIGS. 67 and 68. The vent 720 preferably includes a vent member 722. The vent member 722 generally includes an attaching member 724 for attaching the vent member 722 to the stop member 716. The attaching member 724 extends into the stop member 716. The attaching member 724 includes an elongated stem 726 which is affixed to the stop member 716 by raised protuberances 728 on the elongated stem 726. The attaching member 724 remains stationary with respect to the stop member 716. The vent also includes a vent passageway 730 through the stop member 716 which provides a pathway for the traverse of air when the vent 720 is opened. The vent 720 generally also includes a sealing member 732 which is attached to the attaching member 724. The sealing member 732 is generally a bowl shaped member with the concave open end facing the stop member 716. The open end of the sealing member 732 includes a sealing ring 734 which is that portion of the sealing member 732 that contacts the stop member 716 when the vent 720 is in the closed position. The sealing ring 734 is preferably annularly arranged around the vent passageway 730.

As shown in conjunction with previously shown embodiments, here, activation of the valve 700 is again based on pressure differentials which apply forces which cause the valve 700 to move between a closed and an opened position. The diaphragm 714 is subject to an index pressure which tends to push down on its top surface when the valve is upright as shown in FIG. 66. The diaphragm is also subject to a first force which is operative to keep the stop member 716 within the inner opening 710, and the valve 700 closed. The first force is generally a composite force provided by different sources including a second pressure in passageway 712 pushing up on the diaphragm 714, a resilient force associated with the structure of the diaphragm 714, and a force from the vapor pressure in the container 736 pushing up on the stop member 716.

The index pressure is ambient pressure which supplies a second force in a direction generally opposition to the direction of the first force, and tends to push the deflectable member 714 down when the pressure in passageway 712 is reduced. The pressure in passageway 712 is generally reduced by a user 738 applying a suction force to the outer opening 706, thereby creating a pressure differential between the index pressure and the second pressure. When the second

pressure, or pressure within passageway 712, is sufficiently less than the index pressure, the second force overcomes the first force, and the valve 700 opens.

The vent 720 of this embodiment also functions based on pressure differentials. The sealing member 732 of the vent 720 is exposed to a vapor pressure from within the fluid container 736 when a fluid is in the container on an exterior surface 740, and the index pressure on an interior surface 742. When the vapor pressure within the fluid container 736 is reduced, typically by removing a portion of the fluid contained therein through the valve 700, the index pressure pushing on the interior surface 742 through the vent passage 730, causes the sealing member 732 to flex, and the annularly arranged sealing ring 734 to break its seal with the stop 716. Air then flows into the fluid container 736 until the pressure within the fluid container 736 is substantially equal to the index pressure.

When the pressure within the fluid container 736 is substantially equal to, or greater than, ambient pressure, the force applied to an exterior surface 740 of the sealing member 732 which pushes against the stop member 716 creates or maintains the seal. In this way the vent 720 functions as a one way vent which only allows air or other gases into the fluid container 736, while retaining gases and liquids within the container.

Use of a valve having a vent as disclosed in this embodiment has benefits similar to those described in conjunction with other embodiments of a valve having a vent. These benefits include the reduction of indenting caused by pressure differences inside and outside of semi-rigid containers, and a constant flow rate of fluid out of the valve.

Referring now to FIG. 72, there is shown a cross-sectional view of another embodiment of the vacuum demand flow valve of the present invention, generally referred to with the reference numeral 800, and attached to a fluid container 801. As with previous embodiments, it is understood that the valve 800 can be used with various types of containers generally known for holding flowable substances, without departing from the novel scope of the invention. The structure of the valve 800 will first be described followed by a description of the operation of the valve 800.

As shown in FIGS. 73 and 74, the valve 800 generally includes a housing 802, a diaphragm member 804, and a valve stop member 806. It is understood that the diaphragm 804 and stop member 806 can, in combination, be collectively defined as a member, valve member or stop member. The valve 800 is adapted for connection to the conventional fluid container 801 to enable flowable material to be dispensed from the container 801. The valve 800 is generally responsive to

vacuum pressure or negative pressure applied to the valve 800. As such, the valve 800 is movable between open and closed positions to control fluid flow through the valve 800. In the alternative, it is also contemplated that the valve 800 can be manually depressed by a user in order to control movement of the valve 800 between the open and closed positions. In one preferred embodiment, the container 801 is a carbonated beverage container such as a soda pop bottle. The container 801 could also hold other non-carbonated fluids as well. The container 801 further could be rigid, semi-rigid, or flexible.

The housing 802 has a generally tubular structure defining a passageway 810 for the flowable material to pass therethrough. The housing 802 has a first opening 812 defining a valve outlet 814, located generally at a distal end of the valve 800. The housing 802 further has a second opening 816 defining a valve inlet 818, located generally at a proximal end of the valve 800. The second opening 816 may comprise a plurality of openings. The second opening 816 is adapted for communication with the container 801. The valve outlet 814 and valve inlet 818 enable fluid communication between the valve 800 and the container 801.

The housing 802 generally comprises a port member 880 having a base 805. The base 805 is located at an intermediate location of the port member 880. A first wall 820 extends upwardly from the base 805 and a second wall 822 extends downwardly from the base 805. The base 805 generally supports an inner or internal wall 824.

The second wall 822 provides a mounting surface for the valve 800 to be mounted in sealing engagement with the container 801. In a mounted position, the base 805 is proximate a lip 832 formed generally about the mouth 834 of the container 801. The second wall 822 has threads that mate with corresponding threads on the container 801, thereby providing a sealed connection between the valve 800 and the container 801. Another sealing member (not shown), such as an O-ring, flange, or the like could be used to provide additional sealing.

The port member 880 has an end portion, which generally defines the first opening 812. In an embodiment adapted for direct human use, the port member 880 is configured as a mouthpiece for a user to engage. Notably, the valve 800 and port member 880 can be configured for use in conjunction with a pump, syringe or similar type of fluid handling mechanism generally known to those skilled in the art without departing from the novel scope of the invention.

As further shown in FIGS. 73 and 74, the first wall 820 has an aperture, or opening 836 formed in a generally upper portion of the housing 802. The aperture 836 is configured for

receivable connection with the diaphragm 804. In the present embodiment, the aperture 836 has a generally circular shape, configured to receive the diaphragm 804. Notably, other shapes and configurations are contemplated without departing from the scope of the present invention. The aperture 836 has a rim 838, which is formed generally about the outer edge of the aperture 836 and is configured for receivable engagement with the diaphragm member 804. An abutting edge 840 is also formed about the outer circumference of the aperture 836. The edge 840 and rim 838 cooperatively define a groove 842 therebetween. The groove 842 is adapted for receiving the diaphragm 804 as described in greater detail below.

The second wall 822 extends in a generally downward direction from the base 805. The second wall 822 includes connecting means 850, used for removably connecting the valve 800 to the container 801. In the present embodiment, the connecting means 850 comprise a collar 844 having a series of internal threads 846 formed in the inner surface 848 of the collar 844. The internal threads 846 are adapted for cooperative sealing engagement with outer threads formed on the container 801. Notably, other connecting devices 850 generally known for connecting tops, valves and other like devices to containers can be used to connect the valve member 800 to the container 801, without departing from the scope of the present invention.

The internal wall 824 is positioned within the passageway 810. The internal wall 824 separates the housing 802 into a first housing section 826 defining a first chamber 854, and a second housing section 828 defining a second chamber 856. In this arrangement, the first chamber 854 can be considered to be the downstream portion of the valve 800 and the second chamber 856 can be considered to be the upstream portion of the valve 800.

The internal wall 824 includes an inner opening, or fluid opening 860 formed in the internal wall 824, which can be considered to be the second opening 816. The fluid opening 860 enables fluid communication between the first chamber 854 and the second chamber 856.

The internal wall 824 includes a first or upper surface 866 and an opposing second or underside surface 868. In the present embodiment, the second surface 868 provides a valve seat 870 formed generally about the fluid opening 860. The valve seat 870 is adapted for sealing engagement with the valve stop member 806.

The internal wall 824 has a recessed wall segment 825, formed generally below the internal wall 824, proximate to the inner opening 860. The recessed segment 825 has a generally annular lip formed on the upper surface defining a cradle 864. The cradle 864 is adapted to receive the valve

stop member 806. The recessed segment 825 provides one or more openings 816 for enabling fluid flow into the valve 800. As shown, in the drawings, the recessed segment 825 has plural openings. The recessed segment 825 is configured for containing the valve stop member 806, as will be discussed later. The recessed segment 825 has a height (h), generally less than the height of the valve stop member 806, thereby providing pre-compression of the stop member 806.

The diaphragm 804 is a deflectable, generally resilient member, adapted to be securely connected to the valve housing 802. The diaphragm 804 can be fixed or removably connected to the housing 802. In the connected position, the diaphragm 804 is positioned in the aperture 836 thereby enclosing the first chamber 854. The diaphragm 804 is biased to the position shown in FIG. 73. The diaphragm 804 is formed in a generally circular, concave-shape, however other shapes and configurations are contemplated without departing from the novel scope of the present invention. The diaphragm 804 has a generally central portion 852 and a generally annular peripheral edge 896, which is formed about the outer portion of the diaphragm 804. The edge 896 defines the flange portion 858, which extends in a generally downward direction from the diaphragm 804. The flange portion 858 is configured for receivable engagement with the groove 842, thereby enabling the diaphragm member 804 to be securely connected thereto. The diaphragm member 804 is responsive to vacuum pressure or a depressing force provided by the user. Although one preferred embodiment illustrates a resilient diaphragm member 804, it is contemplated that the member 804 can be any type of deflectable member capable of operating the valve 800.

The diaphragm 804 further includes an extension member 872. The extension member 872 has a generally elongated configuration. The extension member 872 extends in generally a downward direction from a generally central portion of the diaphragm 804 toward the container 801. The extension 872 is connected to the valve stop member 806, such that movement of the diaphragm member 804 is transferred to the valve stop member 806. The connection between the diaphragm 804 and valve stop member 806 can take a variety of different forms including an integral connection or fastened connection performed in a subsequent assembly process. In one preferred embodiment, the extension 872 is adhered to the valve stop member 806. In another preferred embodiment described in greater detail below, the diaphragm 804 and valve stop member 806 are connected in a snap-fit configuration. Preferably, the extension member 872 is generally rigid. However, it is contemplated that the extension 872 can be a resilient member. The member 872 has

an inner channel 876, which extends generally lengthwise through the extension member 872. The channel 876 is in communication with the atmosphere and the valve member 806.

The valve stop member 806 is positioned in the recessed segment 825 for controlling the fluid flow through the valve 800. In the present embodiment, the stop member 806 has a generally bobbin-shaped configuration comprising a central body portion 878, a first or upper resilient portion 874, defining a stop and a second or lower resilient portion 882. In one preferred embodiment wherein the stop member 806 provides for a balanced valve as described in greater detail below, the stop member 806 is generally a symmetrical structure. The first portion 874 is generally identically dimensioned to the second portion 882. The portions are preferably saucer-shaped although it is understood that the first portion 874 and second portion 882 can take a variety of different forms.

The central body portion 878 has a generally cylindrically-shape configuration, although other shapes and configurations are contemplated. The body 878 further comprises an inner channel or conduit 888. The inner channel 888 extends substantially the length of the valve stop body 878. The inner channel 888 is in communication with the channel 876 of the extension 872.

The first portion 874 of the valve stop member 806 has a general concave, incurvate shape, extending generally outwardly upward direction from the body 878 of the valve stop member 806. The first portion 874 of the valve stop member 806 is adapted for sealing engagement with the valve seat 870. The lower portion 882 of the valve stop member 806 is connected to the body 878 and the upper surface 892 of the segment 825. The lower portion 882 extends from the body 878 in a generally outwardly downward direction. The resilient lower portion 882 defines a biasing member 882, which provides a force for urging or biasing the valve member 806, in a generally upward direction toward the valve seat 870. It is understood that the first portion 874 provides a generally equal and opposite force provided by the second portion 882.

The outer edges of the lower portion 882 engage the cradle 864, forming a cavity 890 or a third chamber. The cavity 890 is segregated from communication with the first chamber 854 and second chambers 856. The cavity 890 is in communication with the channel 888, enabling communication between the cavity 890 and the atmosphere via inner channels 876 and 888.

As further shown in FIG. 72, in an assembled state, the valve stop 806 is positioned in the recessed segment 825. As such, the lower portion 882 of the stop 806 engages the upper portion of the recessed segment 825. The stop member 806 is connected to the diaphragm member 804 via the extension member 872. The diaphragm 804 is positioned over the aperture 836 and is connected to

the housing 802 and fits in the groove portion 842 formed about the rim. As discussed, the stop member 806 is in a pre-compressed state.

FIGS. 75 and 76 illustrate the operation of the valve 800. As illustrated in FIG. 75, in an initial state, the valve 800 is in a generally closed, first position. Because the height of the valve stop 806 is greater than the height h defined by the recessed segment 825, the valve stop 806 is in a pre-compressed state. The lower portion 882 of the valve stop 806 or biasing member 882 exerts a biasing force on the valve stop member 806, urging the upper portion 874 of the valve stop 806 into sealing engagement with the valve seat 870 and thus closing the opening 860. It is understood that based on the structure of the valve stop 806, the upper portion 874 provides a generally equal and opposite force on the valve stop 806. Thus, the valve stop 806 is in a balanced condition. The diaphragm 804 is structured and dimensioned such at the diaphragm 804 does not, itself, generally exert a closing force, or upward force on the valve stop 806 when in the closed position. In other alternative embodiments described in greater detail below, the diaphragm 804 could be configured to provide additional forces in the closed position. Thus, in one general preferred embodiment, the stop member 806 provides a biasing force to keep the valve 800 closed. Accordingly, the valve member, in combination, is subject to a first force operative to keep the valve closed. In the first position, the first chamber 854 has a first volume V1, the second chamber 856 has a second volume V2, and the cavity or third chamber 890 has a third volume V3.

An external surface of the diaphragm 804, and connected valve stop member 806, are generally subject to, and sensitive to, an index pressure PI. The index pressure could be, for example, ambient pressure. The valve member is indexed against this index pressure PI. The first chamber 854 is also generally subject to a pressure P1, which could be approximately equal to or greater than the index pressure PI.

The second chamber 856 and container 801 have a pressure PC, which can also be at an ambient pressure or another pressure substantially equal to or greater than the index pressure PI. The pressure PC is a greater pressure when the fluid in the container 801 is, for example, carbonated. The container pressure PC acts on the valve stop 806. The valve stop 806, however, is a balanced member wherein the valve stop 806 is capable of balancing the internal forces acting on the valve stop 806 as provided by the container pressure PC. Thus, the valve stop 806 balances the forces acting on the stop 806 from the container pressure PC. The third chamber 890 is in

communication with the environment and has a pressure PT which is generally equal to the index pressure PI, which could be ambient pressure, outside the container 801.

As shown in FIG. 76, when a suction or vacuum acts on the valve 800, such as a person sucking on the port 880, the pressure in the first chamber 854 of the passageway 810 is lowered to a reduced pressure level P2, generally lower than the index pressure PI. This partial vacuum provides a pressure less than the index pressure PI and acts on a lower surface of the diaphragm 804 causing the index pressure PI on the upper surface of the diaphragm 804 to apply a force on the diaphragm 804 generally equal to the difference between the index pressure and the pressure of the partial vacuum, multiplied times the area of the diaphragm 804, drawing the diaphragm 804 downwards. It is appreciated that the diaphragm 804 in FIG. 76 has moved downwards compared to its initial position in FIG. 75. This force urges the diaphragm 804 in a generally downward direction moving the diaphragm 804 into the first chamber 854, and into a second position and reducing the volume in the first chamber 854.

The diaphragm 804 is connected to the valve stop 806 such that when the diaphragm 804 is drawn into the first chamber 854, the diaphragm 804 exerts a force on the valve stop 806 and drawing the valve stop 806 downwards as shown in FIG. 76. This force unseats the upper portion of the valve stop 806 from engagement with the inner opening 860. When the force applied to the diaphragm 804 is greater than the forces of the valve stop 806 that maintain the valve member 806 in seated engagement with the opening 860, the valve 800 opens. The lower portion 882 of the valve member 806 deflects and is urged toward the upper surface of the internal wall 824, decreasing the volume V3 of the third chamber 890. The channels 876 and 888, in communication with the atmosphere, assist in this movement as is understood. In this embodiment, the valve stop 806 provides the force to maintain the valve in a closed position. It is understood that this force can be alternatively provided as described above.

In the second position, the first chamber 854 has a second volume, which is generally less than the first volume V1. In this position, the flowable material such as fluid or air, is allowed to flow from the container 801 through the inner opening 860 in the direction of arrow B, through the passageway 810 and out of the first opening 812. Thus when a vacuum is applied, a force is applied to the housing 802 in a first direction in response to the vacuum thereby placing the passageway 810 in a second position wherein fluid flows through the passageway in a second position. When the valve stop member 806 in the second position, the third chamber 890 is in vented communication

with the environment enabling the pressure PT in the third chamber to be maintained at a level generally equal to the index pressure or ambient pressure. Thus, when a differential between the second pressure and the index pressure is provided to the valve member, the valve 800 opens when the second pressure is sufficiently less than the index pressure to overcome the first force that operates on the valve member to keep the valve closed. Because the valve member balances any internal forces acting on the valve such as from container pressure PC, the second pressure required to be applied to open the valve is independent of container pressure. Accordingly, the valve 800 can operate independent of container pressure PC.

As shown in FIG. 75, once the vacuum is removed, the valve 800 returns to the first or closed position. Thus, when the second pressure is substantially equal to or greater than the index pressure, the valve closes. The resiliency of the diaphragm 804 removes any force applied to the stop member 806. The second biasing member 882 of the valve member 806 biases the stop member 806 against the valve seat 870, thereby closing the inner opening 860, shutting off fluid communication through the valve 800. Fluid that passes through the port member 880, after the vacuum has been removed is consumed by the user. The change between the first volume V1 and the second volume provide for an action that serves to withdraw the fluid from the outlet back into the outlet passageway such that the linear distance the fluid is withdrawn into the outlet passageway is equal to the difference between the second volume and the volume V1 divided by the area of the outlet which is sufficient to draw the fluid toward the passageway and away from the outlet. The port 880 may be provided with an orifice as described above in previous embodiments.

It is understood that the balanced valve 800 can have similar applications to the embodiments previously described. The vacuum to operate the valve is typically applied by a user, however, other means as previously described are possible. It is also understood that the designations of "first" and "second" with respect to the chambers, pressures and valve positions can be interchanged. The passageway 810 of the valve 800 has an offset configuration wherein the outlet 814 is offset from the inlet 818. It is understood that the valve 800 can be structured such that the outlet 814 is in linear alignment with the inlet 818.

As discussed, the valve 800 provides structure to form a valve having a balanced condition, or balanced valve. The balanced valve provides several advantages. First, it is appreciated that the valve structure is capable of balancing the internal forces acting on the valve such as from fluid pressure in the container. Thus, the valve can operate independent of the container pressure. Extra

effort is not required to open the valve if a container pressure exists. The balance valve enables low suction opening of the valve even at high internal pressure levels. In particular, the configuration of the valve stop member 806 provides that the internal pressure acting on the valve stop member 806 is equally balanced or distributed about the outer surfaces of the portions of the stop member such that the valve stop member is not forced in either an open or closed position by the fluid pressure of the container. Thus, the operation of the valve is not affected by the container pressure. The valve members are capable of having a variety of different members including members with bellow assemblies, washer members, u-members or see-saw members. Valve members having separate spring members or sliding member can also be used to achieve a balanced valve. Other structures are also possible.

In addition to the benefits provided by the balanced valve 800, it is further understood that the structure of the valve stop member 806 can have different structures to alter the operational parameters of the valve. In some circumstances, the varied structure will move the valve away from a balanced condition. For example, it may be desired to change the forces provided by the first portion and second portion of the valve stop member 806. The height of either the stop member 806 or the recessed segment 825 of the internal wall 824 may also be changed. The operative areas or diameters of the first portion 874 and the second portion 882 of the stop member 806 can also be varied to alter the operation of the stop 806. For example, it may be desired for a greater force to be exerted on the first portion 874 of the stop member 806 that forms the seal around the inner opening. In such case, the stop member 806 can be formed such that the area of the first portion 874 is greater than the area of the second portion 882. Accordingly, it is understood that with a greater operative area of the first portion 874, the container pressure PC will provide a greater force (F=P*A) on the first portion 874 than on the second portion 882 wherein a seal of greater magnitude is provided against the internal wall 824 when subjected to container pressure PC. It may also be desired for the stop member 806 to be formed such that the area of the second portion 882 is greater than the area of the first portion 874. Accordingly, it is understood that container pressure PC will provide a greater force (F=P*A) on the second portion 882 than on the first portion 874. As container pressure PC increases, the force exerted on the second portion 882 will be great enough to pull the first portion 874 away from the internal wall 824 and relieve container pressure PC, thus functioning as a pressure relief valve.

It is further understood that when the valve 800 is a balance valve, the diaphragm 804 does not provide any force to the stop 806 when the valve is in a generally closed state. However, the structure of the diaphragm 804 can be varied as desired so that the diaphragm 804 could provide different forces to the stop member 806 when the valve is either closed, opening, in a general opened state or when the valve is closed. For example, the diaphragm 804 could be structured to that it provides an upward force on the stop when the valve is in the closed position, thus providing additional sealing force.

It is further understood that the stop member 806 is preferably an elastomeric member. The saucer-shaped first portion and second portions of the stop member 806 provide for a design that is close to bi-stable member. The stop member 806 can be formed from a number of different materials. The durometer of the stop member 806 could also be varied as desired. The pre-compression of the stop member 806 when the valve is in the closed position could also be varied as desired such as by varying the height of the stop member 806 or of the recessed segment. It is further understood that with the design of the stop member 806, once the valve moves to an open position, the stop member is in a slightly less than a stable position requiring less force to keep the valve open. Thus, less force is requires to maintain the valve in an open position. In general, the structure and properties of the stop member 806 can be varied according to the desired operational characteristics of the valve.

FIGS. 77-79 illustrate another embodiment of the vacuum demand flow valve of the present invention generally referred to with the reference numeral 900. The valve 900 is adapted to be connected to a container 901. The valve 900 generally includes a housing 902, a diaphragm assembly 904, and a stop member 906.

The housing 902 provides a passageway 910 for flowable material to pass from the container 901 through the valve 900. The valve housing 902 generally comprises a first opening 912 defining a valve outlet 914 and one or more second openings 916 defining a valve inlet 918. The passageway 910 is positioned between the valve outlet 914 and the valve inlet 918 thereby enabling fluid to flow from the container 901 and through the housing 902.

The housing 902 comprises an internal wall 922 and a cap member 920. The cap member 920, in cooperation with the internal wall 922, forms a first housing section 926, generally defining a first chamber 954. The cap member 920 is positioned along an outer portion of the valve housing

902 defining an outer cap or top portion. The cap member 920 includes a vent 921. The vent 921 provides for pressure relief of the first chamber 954.

The cap member 920 further includes a port member 980. In this embodiment, the port member 980 is connected to the housing 902 and extends in a generally upward direction from a generally central portion of the cap member 920. The port member 980 has an end portion defining the first opening 912 located at the proximal end of the valve 900. Preferably, the port member 980 has a generally tubular-shape, which extends in a generally upward direction from the housing 902. In an embodiment adapted for direct human use, the port member 980 is configured to enable a user's mouth to comfortably engage the port member 980. Notably, the valve 900 and port member 980 can be configured for use in conjunction with a pump, syringe or similar type of fluid handling mechanisms generally known to those skilled in the art without departing from the novel scope of the invention.

The internal wall 922 is positioned in the passageway 910, generally intermediate to the cap member 920 and the container 901, thereby defining the first chamber 954 and the second chamber 956. The internal wall 922 has a first or upper surface 942 and a second or lower surface 940. The upper surface 942 of the internal wall 922 engages the lower portion of the diaphragm member 904. The lower surface of the internal wall 922 provides a base 930 which enables the valve 900 to be placed in sealing engagement with the container 901. The internal wall 922 provides an inner opening 960 formed therein to enable fluid communication between the first chamber 954 and second chamber 956. The lower surface 944 also provides a valve seat 970, configured for sealing engagement with an upper portion of the valve stop member 906 for sealing the opening 960.

The internal wall 922 has connecting means 950 used for securely connecting to the valve 900 to the container 901. In this embodiment the connecting means 950 are integrally connected to the cap member 920 in the form of a generally threaded skirt 944. The connecting means 950 are formed in a generally cylindrical shape and extend in a generally downward direction. The connecting means 950 comprise a series of internal threads 946. The internal threads 946 are adapted for threaded connected with the outer threads formed on the outer portion of the mouth of the container 901, such that the valve 900 can be securely fastened to the container 901.

The internal wall 922 includes a recessed segment 925. The recessed segment 925 is positioned generally below the internal wall 922 proximate the inner opening 960. The recessed segment 925 is configured to receive the valve stop member 906. The recessed segment 925

includes one or more openings 916 for receiving flowable material from the fluid container 901. The openings 916, like the inner opening 960 can be considered second openings. The recessed segment 925 has a generally annular lip 986 formed on the upper surface defining a cradle 964. The cradle 964 is adapted to receive the valve stop member 906. As shown, in the drawings, the recessed segment 925 has plural openings. The recessed segment 925 is configured for containing the valve member 906, as will be described herein later. The recessed segment 925 has a height (h), generally less than the height of the valve stop member 906, thereby enabling pre-compression of the stop member 906.

The diaphragm assembly 904 includes a diaphragm 907 and a bellows member 908. The bellows member 908 is secured to the housing 902 generally at the proximal end of the port member, generally coaxial to the opening 912. It is noted that in this embodiment, the outlet opening 912 is linearly aligned with the inlet opening 960 or inner opening 960. The bellows member 908 extends in a generally downward direction from the opening 912. The lower portion of the bellows member 908 is connected to the upper portion of the diaphragm 907. The bellows member 908 comprises a generally flexible, resilient material, which enables the bellows member 908 to flex (i.e. extend and contract) responsive to movement of the diaphragm 907. The bellows member 908 has a generally cylindrical configuration. The bellows member 908 has a series of accordian-type folds, enabling the bellows member 908 to flex between an expanded and contracted condition. The bellows member 908 engages the diaphragm 907 providing support to the diaphragm 907 enabling controlled movement of the diaphragm 907 between the open and closed positions.

The diaphragm 907 or biasing member is positioned in the first chamber 954, generally intermediate to, or between, the cap member 920 and the internal wall 922. The diaphragm 907 is responsive to vacuum or negative pressure applied to the valve 900. Preferably, the diaphragm 907 is a rolling diaphragm 907 having a generally flexible outer circumferential portion 994. The central portion of the diaphragm 907 is generally rigid. The outer portion 994 is secured to the housing 902, enabling the diaphragm 907 to reciprocate within the first chamber 954. As shown in the drawings, the outer edges of the flexible outer circumference of the diaphragm 907 are fastened between the cap member 920 and the internal wall 922. In another embodiment, the diaphragm 907 is a generally resilient member, capable of providing a biasing force.

The diaphragm 907 includes an extension member 998. The extension member 998 extends between the valve member 906 and the diaphragm member 907, connecting the diaphragm 907 and

the valve member 906 to each other. The extension member 998 has an elongated portion and a ball-shaped portion, configured for connection with the valve stop member 906. The extension member 998 includes a channel 988 extending lengthwise through the body of the extension member 998. The channel 988 is in communication with the atmosphere and the valve stop member 906. Preferably, the extension 998 has a generally rigid body portion. The extension 998 extends in a generally downward direction from a generally central portion of the diaphragm 907 toward the container 901. The extension 998 is integrally connected to the valve member 906 thereby enabling the diaphragm 907 or control assembly to control movement of the valve member 906.

The valve stop member 906 controls the fluid flow through the valve 900 by controlling the flow of fluid between the chambers 954 and 956. In the present embodiment, the valve member 900 has a generally flexible bobbin-shape configuration comprising a central body portion 978, a first or upper resilient portion 974 defining a valve stop 976 and a second or lower resilient portion 982.

The valve stop body 978 has a generally cylindrically-shape configuration, although other shapes and configurations are contemplated. The valve stop body 978 further comprises an inner channel 996 or conduit. The inner channel 996 extends substantially the length of the body 978. As such, the inner channel 996 is in communication with the channel 988 of the extension 998. The valve stop 906 further provides an opening for connection to the extension member 998 of the diaphragm 904.

The first portion 974 of the valve stop member 906 has a general concave, incurvate shape, extending generally upwardly outward from the body 978. The first portion 974 is adapted to provide sealing engagement with the opening 960 by engaging the valve seat 970. The lower portion 982 of the valve stop member 906 is connected to the body 978 and engages the upper surface of the segment 925. The lower portion 982 extends from the body 978 in a generally outwardly downward direction towards the segment 925. The outer edges of the lower portion 982 engage a lip portion 986 thereby forming a cavity 990 between the lower portion 982 of the valve member 906 and the first surface 984 of the segment. The valve stop member 906 is positioned in the recessed segment 925 for controlling fluid flow through the opening into the first chamber 954.

The resilient lower portion 982 provides a balancing force which urges or biases the valve member 906, particularly the first portion 974 in a generally upward direction into secure connection with the valve seat 970 in a closed position. The resilient lower portion 982 engages the surface of the recessed segment 925, forming the cavity 990 or third chamber. The cavity 990 is segregated

from communication with the first and second chambers 954,956 by the lower portion 982. The channel 996 formed in the valve body 978 enables the third chamber 990 to vent pressure in the cavity to the atmosphere via inner channels 996 and 988. It is further noted that in this embodiment, the passageway is formed through a central opening in the diaphragm member 907 and bellows member 908.

FIGS. 78 and 79 illustrate the operation of the valve 900. As illustrated in FIG. 78, in an initial state, the valve 900 is in a generally closed, first position. The second resilient lower portion 982 of the valve stop member 906 exerts a biasing force on the valve stop member 906 such that the first resilient portion 974 forms a seal against the valve seat 970. It is understood that the valve stop 906 is structured so that the valve stop 906 is balanced as described above. The diaphragm 907 is positioned proximate the underside surface of the cap and the bellows member 908 is in a generally contracted state of equilibrium. The bellows member 908 and diaphragm 907 do not generally provide an upward bias on the valve stop in the closed condition. In this first position, the first chamber 954 of the passageway 910 has a first volume V1, the second chamber 956 has a second volume V2, and the third chamber 990 has a third volume V3.

An external surface of the diaphragm 907 and connected valve stop member 906, are generally subject to, and sensitive to an index pressure PI. The index pressure could be, for example, ambient pressure with the diaphragm 907. The valve 900 is indexed against this pressure PI. The first chamber 954 is also generally subject to a pressure P1 which could be approximately equal to or greater than the index pressure PI.

The second chamber 956 and communicating container 901 have a pressure PC, which can also be at an ambient pressure or another pressure substantially equal to or greater than the index pressure PI. The third chamber 990 in communication with the environment has a pressure PT which is generally equal to the ambient pressure PI outside the container 901. The valve stop 906 is a balanced member that balances the internal forces as provided by the container pressure PC.

As shown in FIG. 79, when a suction or vacuum acts on the valve 900, the pressure in the first chamber 954 is lowered to a reduced pressure level P2, generally lower than the index pressure PI. This vacuum creates an internal suction force on the inner surface of the diaphragm 907, causing the index pressure on the upper surface of the diaphragm 907 to apply a force on the diaphragm 907 generally equal to the difference between the index pressure and the pressure of the partial vacuum, times the area of the diaphragm 904. This force urges the diaphragm 907 in a generally downward

direction, thereby moving the diaphragm 907 into the first chamber 954, into a second position. Further the bellows member 908 is expanded into an extended condition into the first chamber 954 and further reducing the volume in the first chamber 954. In this embodiment, it is noted that the outlet 914 and inlet 918 of the passageway are linearly aligned. Thus, the partial vacuum is applied at the outlet 914 where it acts upon a lower surface of the diaphragm 907 after passing through the bellows member 908 and through the central opening in the diaphragm 907.

The diaphragm 907 is connected to the valve member 906 and the bellows member 908, such that when the diaphragm 907 is drawn into the first chamber 954, the diaphragm 907 exerts a force unseating the upper portion 974 of the valve stop member 906 from engagement with the opening 960. This occurs when the force applied overcomes the first force associated with the stop member 906 that maintains the stop member 906 in engagement with the inner opening 960. The lower portion 982 of the valve member 906 is urged toward the recessed segment 925, decreasing the volume of the cavity 990.

In the second position, the first chamber 954 has a second volume, which is generally less than the first volume V1. In this position, the flowable material such as fluid or air, is allowed to flow from the container 901 through the inner opening 960 in the direction of arrow B, through the passageway 910 and out of the first opening 912. Thus, when a vacuum is applied, a force is applied to the housing 902 in a first direction in response to the vacuum thereby placing the valve member 906 in a second position wherein fluid flows through the passageway 910 in a second position. When the valve member 906 is in the second position, the third chamber 990 is in vented communication with the environment enabling the pressure PT in the third chamber 990 to be maintained at a level generally equal to the index pressure or ambient pressure.

Once the vacuum is removed, as shown in FIG. 78, the valve 900 returns to the first or closed position. Thus, when the second pressure is substantially equal to or greater than the index pressure, the valve closes. The resiliency of the lower portion, or second resilient member 982 of the valve stop member 906 biases the stop member 906 against the valve seat 970 to close the inner opening 960, shutting off fluid communication through the valve 900. The bellows member 908 also assists in drawing the diaphragm 907 upwards.

FIG. 80 discloses a cross-sectional view of another embodiment of the vacuum demand flow valve, generally referred to as the reference numeral 1000. The valve 1000 is attached to a fluid container 1001 to enable controlled fluid flow from the container 1001. The valve 1000 is movable

between the open and closed position in response to a vacuum or negative pressure applied to the valve 1000 by a user. In the alternative, the valve 1000, can be manually depressed by a user to move the valve 1000 between the open and closed position. As shown, the valve 1000 generally comprises a housing 1002, and a diaphragm assembly 1008 and a stop member 1006.

The housing 1002 generally defines a passageway 1010. The valve 1000 comprises a first opening 1012 defining a valve outlet 1014 and a second opening 1016 defining a valve inlet 1018. The passageway 1010 is positioned between the valve outlet 1014 and the valve inlet 1018 to facilitate fluid to flow through the housing 1002.

The housing 1002 comprises a base member1022 and a cap member 1020. The base member 1022 comprises a first wall 1023 defining an aperture, a second wall 1024, and an internal wall 1025. The first wall 1023 and internal wall 1025 comprise a first housing section 1026, defining a first chamber 1054 and the second wall 1024 and internal wall 1025 comprise a second housing section 1028 defining a second chamber 1056.

The cap member 1020 generally forms the outer portion of the valve 1000. The cap member 1020 includes one or more vents 1021 extending through the cap member 1020 of the housing 1002. The vent 1021 provides an opening enabling communication between the first chamber 1054 and the atmosphere.

The cap member 1020 further comprises a port member 1080. The port member 1080 has a generally cylindrical shaped configuration, which extends in a generally upward direction from a generally central portion of the housing 1002. The port member 1080 has a first or proximal end 1082 and a second or distal end 1084. The opening 1012 is formed generally at the first end 1082 of the port member 1080. The port member 1080 is integrally connected to the housing 1002. In an embodiment adapted for direct human use, the port member 1080 is configured to enable a user's mouth to comfortably engage the port member 1080. Notably, the valve 1000 and port member 1080 can be configured for use in conjunction with a pump, syringe or similar type of fluid handling mechanisms generally known to those skilled in the art without departing from the novel scope of the invention. The port member 1080 extends through the first chamber 1054. As such, the second end 1084 of the member 1080 cooperatively engages a portion of the diaphragm assembly 1008, which will be described later herein.

The second wall 1024 has a generally annular configuration adapted for engagement with the mouth of the container 1001. The second wall 1024 further includes connecting means 1050, which

enable the valve 1000 to be removably connected to the container 1001. In the present embodiment the connecting means 1050 comprise an integral collar 1044 having a series of internal threads 1046 formed in the inner surface 1048 of the collar 1044. The internal threads 1046 are configured for cooperative engagement with outer threads formed on the container 1001. Notably, other connecting means 1050 generally known for connecting tops, valves and other like devices to containers can be used for connecting the valve member 1000 to the container 1001 without departing from the scope of the invention.

The internal wall 1025 is positioned within the passageway 1010 intermediate to the first wall 1020 and second wall 1024, thereby separating the first chamber 1054 and the second chamber 1056. The internal wall 1025 extends into the passageway 1010. The internal wall 1025 has an opening 1060 formed therein and configured to receive a portion of the diaphragm assembly 1008. The internal wall 1025 includes a first or upper surface 1066 and a second or lower surface 1068. The lower surface 1068 of the internal wall 1025 comprises a valve seat 1070. The valve seat 1070 is configured to provide sealing engagement with the flexible member 1006 of the valve assembly 1008.

The diaphragm assembly 1008 is operatively connected to the valve housing 1002 for controlling the flow of fluid through the valve 1000. The diaphragm assembly 1008 generally comprises a first diaphragm member 1004, a control member 1030 operatively connected to the diaphragm member 1004, and a support member 1040.

The diaphragm 1004 is positioned in the first chamber 1054 and is securely connected to the valve housing 1002. As shown, the outer portion of the diaphragm 1004 is fastened between the cap member and the base member, thereby connecting the diaphragm 1004 to the housing. The diaphragm member 1004 is a deflectable, resilient member responsive to vacuum pressure or a depressing force provided by the user to enable the valve 1000 to reciprocate within the first chamber 1054. Preferably, the diaphragm member 1004 is a rolling diaphragm member. The diaphragm 1004 has a central opening 1005 centrally formed therein. The opening 1005 is adapted for receiving the port member 1080 therethrough. The diaphragm 1004 is connected to the port member at the central opening 1005. The diaphragm 1004 provides a generally annular lip portion 1009, configured for connection with an annular groove 1081 formed in the port member 1080.

The first control member 1030 has a first section 1036 and a second section 1038. The first section 1036 is substantially positioned in the first chamber 1054. The first section 1036 has a

generally circular shaped configuration. The first control member 1030 is connected to the diaphragm member 1004 and is responsive to the reciprocating movements of the diaphragm 1004. The second section 1038 has a generally annular shape, which extends through the opening 1060 for supporting engagement with the flexible valve member 1006 .

The support member 1040 engages a lower or bottom portion of the stop member 1006 assisting in providing a balancing force to the member 1006. The control member 1030 in cooperation with the support member 1040 and lower end of the port member 1080 cooperatively engage the valve stop member 1006, thereby cooperatively controlling movement of the valve stop member 1006 between an open and closed position.

The valve stop member 1006 is a generally resilient, a flexible seal member. The valve stop member 1006 may be a member having a bi-stable configuration. In one preferred form of the invention, the stop member 1006 is a belleville washer as is known in the art. The member 1006 has a generally circular configuration. The stop member 1006, being a bistable device, is capable of being flexed between a closed or first position and an open or second position. The stop member 1006 is positioned proximate to the opening 1060 formed in the internal wall 1025 and balanced between the support member 1040 and lower end of the port member 1080 for controlling fluid flow through the opening. A generally outer portion of the flexible member 1006 defines a valve seal, configured for sealing engagement with the valve seat 1070. The control member 1030 engages the outer portion of the stop member 1006, thereby flexing the valve stop 1006 between an open and closed, or sealed position with the valve seat 1070.

FIGS. 81 and 82 illustrate the operation of the valve 1000. As illustrated in FIG. 81, in an initial state, the valve 1000 is in a generally closed, first position. As such, the stop member 1006 exerts a biasing force against the valve seat 1070 and control member 1030 biasing the sealing portion in sealing engagement with the valve seat 1070. In this first position, the first chamber 1054 of the passageway 1010 has a first volume V1 and the second chamber 1056 has a second volume V2.

The diaphragm 1004 and valve member 1006, are generally subject to, and sensitive to an index pressure PI. The index pressure could be, for example, ambient pressure with the diaphragm 1004. The valve 1000 is indexed against this pressure PI. The first chamber 1054 is also generally subject to a pressure P1 which could be approximately equal to or greater than the index pressure PI.

The second chamber 1056 and communicating container 1001 have a pressure PC, which can also be at an ambient pressure or another pressure substantially equal to or greater than the index pressure PI.

As shown in FIG. 82, when a suction or vacuum acts on the valve 1000, the pressure in the first chamber 1054 of the passageway 1010 is lowered to a reduced pressure level P2, generally lower than the index pressure PI. This vacuum creates an internal suction force on the inner surface of the diaphragm 1004, generally equal to the difference between the index pressure and the pressure of the partial vacuum, times the area of the diaphragm 1004. This suction force urges the diaphragm 1004 in a generally downward direction, thereby moving the diaphragm 1004 in the first chamber 1054, into a second position. Further, in response to movement of the diaphragm 1004, the control member 1030 is forced in a generally downward direction into a second position. Movement of the control member 1030 forces the lower section of the member 1030 thereby exerting a force on the outer sealing portion of the stop member 1006. This forces the stop member 1006 to a second position as shown in FIG. 82 thereby unseating the sealing portion of the member 1006 from engagement with the valve seat 1070.

Once the vacuum is removed, as shown in FIG. 81, the valve 1000 returns to the first or closed position. Thus, when the second pressure is substantially equal to or greater than the index pressure, the valve closes. The resiliency of the valve member 1006 biases the valve member 1006 against the valve seat 1070 to close the inner opening 1060, shutting off fluid communication through the valve 1000.

FIGS. 83 and 84 disclose a cross-sectional view of another embodiment of the vacuum demand flow valve 1100. The valve 1100 is adapted for attachment to a fluid container 1101 for controlling dispensing of fluids from the container 1101. The structure of the valve 1100 will first be described followed by a description of the operation of the valve 1100.

As shown in FIG. 83, the valve 1100 generally includes a housing 1102 and a diaphragm assembly 1104. The valve 1100 is movable between an open and closed position in response to a vacuum pressure or negative pressure. Notably, it is also contemplated that the valve 1100 can be manually depressed by a user to control fluid flow through the housing 1102. The valve 1100 has a first opening 1112 defining a valve outlet 1114 and a second opening 1116 defining a valve inlet 1118. The valve inlet 1118 is adapted for communication with the container 1101. The passageway

1110 is positioned between the valve outlet 1114 and valve inlet 1118, thereby enabling fluid to flow through the housing 1102.

The housing 1102 generally comprises a base 1130 having a first wall 1120, a second wall 1122 and an internal wall 1124. As shown, the housing 1102 has a generally cylindrical shaped body. As such, the valve 1100 can be connected to a generally cylindrical or circular shaped mouth of the container 1101. The first wall 1120 and internal wall 1124 form a first housing section 1126 defining a first chamber 1154 and the second wall 1122 and internal wall 1124 form a second housing section 1128 defining a second chamber 1156.

The base portion 1130 is configured to provide sealing engagement with the container 1101. When the valve 1100 is connected to the container 1101, the base 1130 engages a lip portion 1132 formed generally about the container's mouth, thereby providing a surface for the valve 1100 to be mounted onto the container 1101. Preferably, the valve 1100 includes a sealing member 1136 or flange member, such as an O-ring, which can be positioned between the mouth and base 1130 in order to prevent fluid from leaking from the container.

The first wall 1120 extends in a generally upward direction from the base 1130. The first wall 1120 has a generally cylindrical configuration. The first wall 1120 includes a groove 1138 formed therein. The groove 1138 is adapted for receivable connection with the diaphragm assembly 1104, which will be described below. The first wall 1120 further includes one or more vent holes 1121, which extend from the inner surface of the first wall 1120 and through the housing 1102, thereby providing communication therethrough.

The second wall 1122 extends in a generally downward direction from the base 1130. The second wall 1122 has a generally cylindrical shape configured for engagement with the mouth of the container 1101, however, other shapes are contemplated. The second wall 1122 includes connecting means 1150, enabling the housing 1102 to be securely connected to the container 1101. In the present embodiment the connecting means 1150 comprise a collar 1144 having a series of internal threads 1146 formed in the inner surface 1148 of the collar 1144. The collar 1144 is adapted for connection with the outer threads of the container 1101.

The internal wall 1124 extends from a generally inner portion of the housing 1102 into the fluid passageway 1110. The internal wall 1124 has an inner opening 1160 formed between the first housing section 1126 and the second housing section 1128. The opening 1160 is adapted for receivable connection with the diaphragm assembly 1104, which will be discussed below. The

internal wall 1124 includes a recessed segment 1125 formed at a generally lower portion of the internal wall 1124. The recessed segment 1125 extends into a position generally below the diaphragm assembly 1104. The recessed segment 1125 includes an additional inner opening in communication with the inner opening 1160. The additional inner opening defines a valve seat. As such, the segment 1125 provides a surface configured for sealing engagement with the lower portion of the diaphragm assembly 1104 to control fluid flow through the valve 1100.

The diaphragm assembly 1104 is operatively connected with the housing 1102 for controlling fluid flow through the passageway 1110 of the valve 1100. The diaphragm assembly 1104 comprises a first diaphragm member 1107, a first bellows segment 1108, an intermediate portion 1111, a second bellows segment 1109 and a valve stop member 1106. The diaphragm assembly 1104 is responsive to negative or vacuum pressures applied to the housing 1102 thereby forcing the assembly 1104 to reciprocate into an open or closed position within the housing 1102. A central opening or passageway is provided through the diaphragm assembly 1104.

The diaphragm member 1107 is responsive to vacuum pressure applied to the opening 1112 formed in the first valve section. The diaphragm 1107 is connected to the first wall 1120 of the valve housing 1102. The diaphragm 1107 provides a mounting surface enabling connection to the first wall 1120 at the groove portion 1138. The diaphragm member 1107 has a body portion 1162 and a peripheral portion 1158. The peripheral portion 1158 extends from the member 1104, enabling connection with the first wall 1120. The portion 1158 is generally flexible, enabling the diaphragm 1107 to move in an upward and downward direction.

The first bellows segment 1108 is connected to the inner portion of the diaphragm member 1107. The first bellows segment 1108 has flexible structure which flexes between an expanded condition and contracted condition response to the reciprocating movement of the diaphragm member 1107.

The intermediate segment 1111 is connected to the inner portion of opening 1160 formed in the intermediate wall 1120. As such, the intermediate segment 1111 supports the diaphragm assembly 1104 in the housing.

The second bellows member 1109 is connected to the intermediate segment 1111. As such, the second bellows member 1109 extends in a generally downward direction from the intermediate portion 1111 into the second chamber 1156. The second bellows member 1109 is responsive to vacuum pressure applied to the diaphragm assembly 1104 as well as movement of the diaphragm

member 1107. The second bellows member 1109 or second diaphragm member 1109 is responsive to pressure in the valve member 1101. The first bellows member 1108 and second bellows member 1109 are generally coaxial to each other and axially or longitudinally spaced.

The valve stop member 1106 is generally positioned in the second chamber 1156. Reciprocating movement of the valve member moves the valve 1100 into engagement with the segment 1125. As such, the stop member 1106 is configured for sealed engagement with the recessed segment 1125 to control fluid flow through the diaphragm assembly 1104.

In an assembled state, the first diaphragm member 1107 is connected to the inner surface of the first wall 1120. The peripheral edge 1158 engages the groove 1138 formed in the first wall 1120. The first bellows member 1108 is position in the first chamber 1155 and the second bellows segment 1109 extends into the second chamber 1154. The intermediate portion 1111 is connected to the opening 1160 formed in the internal wall 1124.

FIGS. 83 and 84. illustrate the operation of the valve 1100. As illustrated in FIG. 83, in an initial state, the valve 1100 is in a generally closed, first position. The diaphragm 1107 exerts a biasing force F1 on the diaphragm assembly 1104. In this state, the first bellows segment 1108 is in a generally contracted position and the second bellows member extends in a generally downward position, forcing the valve stop 1106 into closed engagement with the valve seal at the recessed segment.

Initially, the valve 1100, particularly the first housing section 1126 and first chamber 1154, are subject to an initial index pressure PI. When a user applies a negative pressure or vacuum to the mouthpiece of the valve 1100, the pressure at the outlet is lowered to a reduced pressure level P2, generally lower than the index pressure PI. This vacuum creates an internal suction force on the inner surface of the diaphragm member 1107, generally equal to the difference between the index pressure and the pressure of the partial vacuum times the area of the member 1107. This suction force urges the diaphragm 1107 towards the outlet opening 1112. Movement of the diaphragm 1107 in the direction of the outlet opening 1112 forces the first bellows member 1108 to extend into an extended condition. Application of the partial vacuum further flexes the second bellows member 1109 towards the diaphragm 1107 thereby unseating the valve stop member 1106 from the valve seat 1170 formed in the recessed segment 1125. As such, a fluid flow path is provided fluid is permitted to flow from the container 1101 and through the inlet 1118 of the valve 1100. It is

understood that the valve returns to its closed position when the vacuum is removed. It is further understood that the valve 1100 is configured as a balanced valve.

FIGS. 85 and 86 disclose a cross-sectional view of another embodiment of the vacuum demand flow valve 1200. The structure of the valve 1200 will first be described followed by a description of the operation of the valve 1200.

As shown in FIG. 85, the valve 1200 generally includes a housing 1202 and a diaphragm assembly 1204 operatively connected to the housing 1202, for controlling fluid flow through the valve 1200. The housing 1202 comprises a valve passageway 1210, a first opening 1212 defining a valve outlet 1214 and a second opening 1216 defining a valve inlet 1218. The valve inlet 1218 enables fluid communication with the container 1201. The passageway 1210 is positioned between the valve outlet 1214 and valve inlet 1218, enabling fluid to flow through the housing 1202.

The passageway 1210 has a first segment 1280 extending in a generally downward direction from the valve outlet 1214, and a second segment 1282 extending generally perpendicular to the valve outlet 1214. The upper portion of the valve inlet provides an opening 1216 coaxially aligned for engagement with the diaphragm assembly 1204, enabling the diaphragm assembly 1204 to control fluid flow through the opening 1216.

The housing 1202 comprises a first wall 1220 generally forming a cap portion. The first wall 1220 has a generally annular shape, configured for connection with the container 1201. The first wall 1220 comprises connecting means 1250 adapted for enabling the valve 1200 to be securely connected to the container 1201. In this embodiment, the first wall 1220 comprises a series of internal threads 1242 formed on the inner surface of the wall 1220. The threads 1242 are adapted for threaded connection with external threads provided on the outer surface of the container 1201. As such, the valve 1200 can be connected to a generally cylindrical or circular shaped mouth of the container 1201. Notably other devices, known for connecting top members to containers, such as a snap-on top are contemplated, without departing from the scope of the present invention.

The housing 1202 further comprises an internal wall 1222. The internal wall 1222 has a circular and inclined configuration forming a generally conical structure. The internal wall 1222 provides a first valve seat 1270 adapted to provide sealing engagement of the valve outlet 1214 with a portion of the diaphragm assembly 1204.

The diaphragm assembly 1204 comprises a first valve stop 1223, a first bellows member 1208 and a second valve stop 1226. The diaphragm assembly 1204 moves between a first, or open

position and a second, or closed position in response to a vacuum pressure or negative pressure applied to the valve 1200. The first valve stop 1223 has a first portion 1262 and a second portion 1264. The first portion 1262 is adapted for sealing engagement with an inner portion of the internal wall 1222. The first valve stop 1223 is responsive to vacuum pressure applied to the housing 1202. The second portion 1264 extends from the first portion 1262 into engagement with the second valve stop 1226.

The bellows member 1208 is a generally flexible member having a flexible foldable body, thereby providing a resilient structure, enabling the bellows 1208 to be moved between an extended condition and a contracted condition. The second valve stop member 1226 is connected to the bellows member 1208 and coaxially aligned with the valve inlet 1216.

In an assembled state, the diaphragm assembly 1204 is connected to the valve housing 1202. The valve stop member 1206 is connected to the second portion 1264 which extends from the stop member 1226.

FIGS. 85 and 86 illustrate the operation of the valve 1200. As illustrated in FIG. 85, in an initial state, the valve 1200 is in a generally closed, first position. In this state, the first bellows segment 1208 is in a generally extended condition. As such, the second valve stop 1226 engages the valve inlet 1216 and the first valve stop 1223 engages the inner wall 1222, proximate to the valve outlet 1212, thereby preventing fluid flow through the valve 1200. It is understood that the first valve stop 1223 could be considered a diaphragm member and could be dimensioned such that the member is positioned inwards of the outlet 1210 where it would not provide an additional stop member.

Initially, the valve 1200 is subject to an initial index pressure PI. When a user applies a negative pressure or vacuum to the mouthpiece of the valve 1200, the first valve stop 1223 is urged upwards away from the valve outlet. Movement of the first valve stop 1223 of the diaphragm assembly 1204 towards the inlet opening 1212 flexes the bellows member 1208. This movement pulls the second valve stop 1226 away from the second opening 1216, thereby providing a fluid flowpath through the valve 1200. When the partial vacuum is removed, the valve 1200 closes.

Valves as described utilizing the bellows assembly provide several advantages. It is independent of container pressure when the valve is closed and also when the valve is open. Accordingly, a spring force associated with the valve needs only to be sufficient to produce a seal, rather than to have the ability to close against the container pressure. The diaphragm is a sealed

arrangement, which is activated against atmospheric pressure, independent of fluid flow through the valve. Furthermore, a maximum diaphragm area is achieved, i.e., the total available area minus the mouthpiece area in the middle. The fluid flowpath is large and nearly linear to optimize fluid flow through the valve. The opening can be biased (i.e, non-proportional) to reduce foaming. In addition, the biasing forces for the valve can be provided by the bellows assembly or the diaphragm outside the body of fluid. The axial action of the bellows assembly is easily suited to a range of anti-drip solutions. A minimal number of components are needed for the valve.

When the valve is actuated, a pressure differential across the diaphragm is maintained to keep the valve open while simultaneously allowing a large fluid flowpath. These are conflicting requirements, the first requiring a small gap around the diaphragm and the other requiring a large gap around the diaphragm. The bellows assembly allows these areas to be separated and sealed from each other, with the annular actuation area acting against atmospheric pressure at all times. The diaphragm can be a rolling diaphragm or a membrane diaphragm, as well as a flexible disc member. The bellows assembly is structured wherein the fluid pressure in the container acts on the surface area of the bellows in a balanced fashion. Accordingly, the spring force does not need to overcome the pressure on the valve bottom but instead needs only to provide the force to produce a good seal at pressures in the container. The structure of the bellows assembly can be altered to either increase or decrease the axial force provided by the bellows if desired.

The valve provides a biased movement. There is no movement of the valve until a certain force is reached on the valve. At that force, the valve moves significantly. The valve can be maintained either with the same force or with a lesser force. The mechanism producing this action can be part of the bellows assembly or part of the diaphragm. This is desirable as it allows for a non-proportional valve that opens suddenly rather than gradually. This helps reduce foaming if certain carbonated beverages are held in the container. Foaming may occur with some carbonated fluids when passing through a small opening. With the bellows assembly as shown in FIGS. 83 and 84, the highest suction is required from the user at the beginning to open the valve. Once the valve is open, the biased action means that less of a force is required from the user suction. The suction is likely to reduce naturally as the fluid flows.

The bellows assembly can be made from plastic. The assembly can be predominantly thick, rigid plastic with only localized areas that are thin and flexible.

Another advantage is that as long as the upper and lower connection points of the bellows assembly occupy the same diameter, there will be generally no net force on the bellows assembly from the fluid surrounding the bellows.

The actuation diaphragm is close to the mouth of the user and the actuation diaphragm acts against atmospheric pressure rather than having fluid flow on the underside of the diaphragm which might cause some delay in closing.

In sum, the valves utilizing the bellows assembly are simple in construction. The valves balance the internal container pressures and provide a large straight flowpath. In addition, the non-proportional nature of the bellows assembly gives larger valve opening geometry. The bellows assembly structure can be modified to allow for operation at greater pressures, provide greater sealing force such as from compliant seals, areas and bellows convolution and edge activation.

Balanced valves will balance the internal forces acting on the valve such as from the fluid pressure in the container. A balanced valve enables low suction opening of the valve even at high internal pressure levels. The valves are capable of having a variety of different members including u-members, washer members and see-saw members.

The valve components can be made from a variety of materials. The materials can be selected based on the intended use of the valve. In one embodiment, such as the valve being used with drink containers, the valve components can be made from a variety of polymers or other structurally suitable materials. Other materials are also possible. The choice of materials is only related to the fluid and use the valve is to be applied to. For example, should this valve be used in the fuel or oxidizer supply section of a rocket engine with an injection pump providing a partial vacuum and the index pressure externally applied; the valve member and housing may be made out of stainless steel.

The valves disclosed provide several benefits. The containers and valves are low-cost and designed for single-use consumption wherein the container and valve can be discarded when the container is empty. The valve, however, could also be used in multi-use applications. The valve is suction-activated wherein the user can drink through the valve as easily as with a conventional straw. The housing structure and valve function also prevent dripping from the valve. The structure of the valve prevents fluid from being drawn back into the container once through the internal opening. The structure of the valve also resists pressure from the container and cannot be accidently activated. The valve is not required to be recapped once opened as the valve returns to its closed

position upon non-use. The valve components are easily manufactured such as by an injection-molded process in one preferred embodiment. Because the valve can be constructed from certain injection-moldable materials, the valve can be operable through a broad range of temperatures and for extended periods of time.

Referring now to FIGS. 87-90, there is shown another embodiment of the vacuum demand flow valve 1300, connected to a fluid container 1301. The valve 1300 generally includes a housing 1302 and a diaphragm assembly 1304, operatively connected to the housing 1302 for controlling the flow of fluid through the valve 1300.

The valve housing 1302 comprises a first opening 1312 defining a valve outlet 1314 and a second opening 1316 defining a valve inlet 1318. A passageway 1310 is positioned between the valve outlet 1314 and the valve inlet 1318, thereby enabling fluid to flow through the housing 1302. The valve housing 1302 comprises a cap member 1320 and a port assembly 1322.

The cap member 1320 has a base 1305, a first wall 1324, and a second wall 1326. The first wall 1324 extends from the base 1305 generally along an outer portion of the valve housing 1302, thereby defining a top portion. The first wall 1324 has a generally circular configuration, however, other shapes and configurations are contemplated, without departing from the scope of the present invention. The first wall 1324 has a central opening 1323 adapted to receive the port assembly 1322, which will be described herein later.

The second wall 1326 extends in a generally downward direction from the base 1305 and the first wall 1324. The second wall 1326 is formed in a generally cylindrically-shaped configuration, enabling the cap member 1320 to be connected with the mouth of the container 1301. The second wall 1326 includes connecting means 1350 for securing the valve 1300 to the container 1301. In this embodiment, the connecting means 1350 include a series of threads 1342 formed on the inner surface of the second wall 1326. The threads 1342 are adapted for cooperative connection with external threads formed about the mouth of the beverage container 1301.

The port assembly 1322 includes a spout 1328, an internal wall 1332 depending from the spout 1324, and a third wall 1334. The port assembly 1322 is configured to facilitate fluid flow through the valve 1300. The spout 1328, the internal wall 1332, and third wall 1334 are integrally connected to each other defining a first chamber 1354.

The spout 1328 extends in a generally upward direction from the internal wall 1332, defining a port member 1380. In an embodiment adapted for direct human use, the port member 1380 is

configured to enable a user's mouth to comfortably engage the port member 1380. Notably, the valve 1300 and port member 1380 can be configured for use in conjunction with a pump, syringe or similar type of fluid handling mechanisms generally known to those skilled in the art without departing from the novel scope of the invention. Notably other spout-like devices generally known in the art can be used to facilitate the flow of fluid from the container 1301 without departing from the scope of the present invention.

The internal wall 1332 has a generally inclined configuration, extending in a generally inwardly downward direction from the spout 1328, thereby forming a generally conically shaped portion, adapted for facilitating fluid flow through the valve 1300. The internal wall 1332 and third wall 1334 intersect at a point, indicated at 1398. At the point indicated at 1398, a first valve seat 1390 is formed. The valve seat 1390 is adapted to receive a portion of the diaphragm assembly 1304. The third wall 1334 has a generally cylindrical shape defining a second chamber 1356. As shown, the third wall 1334 has a plurality of inlet openings 1316 enabling fluid flow into the valve 1300.

The diaphragm assembly 1304 is operatively connected to the valve housing 1302 for the control of fluid flow through the valve 1300. The diaphragm assembly 1304 includes a plunger member 1308, a diaphragm 1307, a retainer or first support member 1372, a biasing member 1376 and one or more valve stop members 1306.

As shown in FIGS. 89 and 90, the plunger 1308 has a first lateral portion 1360 defining a first valve stop 1309 adapted for sealing engagement with the first valve seat 1390. The plunger 1308 further has longitudinal member 1362 having a generally elongated configuration. The longitudinal member 1362 extends generally perpendicularly downwardly from the lateral portion 1360 through the first chamber 1354. The plunger 1308 extends though an opening formed in the support member 1372 and is operatively connected to the diaphragm 1307. The plunger member 1308, responsive to a vacuum or negative pressures applied to the valve 1300, is movable between a first position and second position.

The support member 1372 is positioned in the second housing section 1329. The support member 1372 extends about the circumference of the second housing section defining a third chamber 1390. The support member 1372 provides a central opening 1373 for receiving a portion of the plunger 1308 therethrough.

As shown in FIG. 88, the diaphragm 1307 has a top surface 1394 and a lower surface 1396. The top surface is connected to a lower portion of the third wall 1334, thereby sealing the bottom portion of the second housing section 1329. The top surface 1394 of the diaphragm member 1307 is connected to the end portion of the plunger member 1308 such that movement of the plunger member 1308 moves the diaphragm member 1307.

The biasing member 1376 is positioned between the support member 1372 and diaphragm 1307. In the present embodiment the biasing member 1376 is a spring, however it is contemplated that the biasing member 1376 can be any type of spring or resilient member generally known to those skilled in the art. The first end of the biasing member engages a lower surface of the support member and a second end engages the top surface 1394 of the diaphragm 1307.

As shown, the valve stop member 1306 is coupled to the diaphragm member 1307. Preferably, the stop member 1306 comprises a pair of stop members 1306 collectively being a generally a U-shaped stop member. Each stop member 1306 has a first member 1384 and a second member 1386. As shown, the stop member 1306 has a first member 1384 fixedly attached to the diaphragm 1307 and a second member 1386 extending generally perpendicularly from the first member 1384. In this configuration, the second member 1386 is configured for engagement with the outer surface of the third wall 1334, thereby providing sealing engagement with the inlet opening 1316. The valve stop member 1306 includes a generally resilient sealing member 1392 affixed to the second member 1386, and adapted for providing sealing engagement with the inlet opening 1318. As shown in the drawings, the diaphragm assembly 1304 can include plural stop members 1306a and 1306b, configured to provide sealing engagement with respective plural inlet openings 1318.

FIGS. 89 and 90 illustrate the operation of the valve 1300. As illustrated in FIG. 89, in an initial state, the valve 1300 is in a generally closed, first position. As such, the biasing member 1376 exerts a biasing force on the support member 1372 and the diaphragm member 1307. The biasing force applied to the diaphragm 1307 forces the diaphragm 1307 into a generally planar extended formation. As such, the diaphragm 1307 forces the connected first member 1384 of the valve stop member 1306 into a generally parallel position relative to the diaphragm 1307. In this position, the second member 1386, which extends in a generally perpendicular position from the first member 1384, is positioned generally parallel to the outer surface of the third wall 1334. As

such, the sealing surface engages the inlet opening 1316, thereby preventing fluid from entering the second chamber 1356.

Initially, the valve, particularly the first chamber 1354, is subject to an initial index pressure PI. When a user applies a negative pressure or vacuum to the mouthpiece of the valve 1300, sucking on the port 1380, the pressure in the first chamber 1354 of the passageway 1310 is lowered to a reduced pressure level P2, generally lower than the index pressure PI. This vacuum urges the plunger 1308 towards the outlet 1312.

Movement of the plunger 1308 towards the outlet opening 1312 unseats the plunger 1308 from contact with the valve seat 1398. Further, the plunger draws a portion of the diaphragm 1307 into the third chamber 1390. Movement of the diaphragm 1307 into the third chamber 1390, forces the first member 1384 of the stop member 1306 into the third chamber 1390 and cooperatively pivots the second member 1386 of the stop member 1306 away from engagement with the outer surface of third wall 1334. Movement of the stop member 1306 away from the inlet opening thereby enables fluid to flow into the inlet opening 1316 and through the valve 1300. In a preferred embodiment, the stop member 1306 pivots generally about a central portion of the diaphragm 1307.

It can be appreciated that the valve 1300 is also a balanced valve. The valve 1300 will operate independent of the container pressure.

It is understood that the valves of FIGS. 72-87 may have similar outer structures to the valve embodiments previously described. The outer structures could also vary without departing from the functional aspects of the valves as disclosed. Those skilled in the art will understand the operation and utility of the valves from the drawings and written description.

It will further be understood that the features of the several different embodiments of the vacuum demand flow valves described herein are complementary. Different features of the valves may be incorporated into valve designs as desired to create additional embodiments of the valve of the present invention.

It will be understood that the invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present embodiments, therefore, are to be considered in all respects illustrative and not restrictive, and the invention is not to be limited to the details given herein.